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POLLUTION OF RARITAN BAY AND ADJACENT INTERSTATE WATERS. PROCEEDINGS OF CONFERENCE, THIRD SESSION, HELD AT NEW YORK, NEW YORK ON JUNE 13-14, 1967. VOLUME 1

Federal Water Pollution Control
Administration
Washington, D. C.

June 1967

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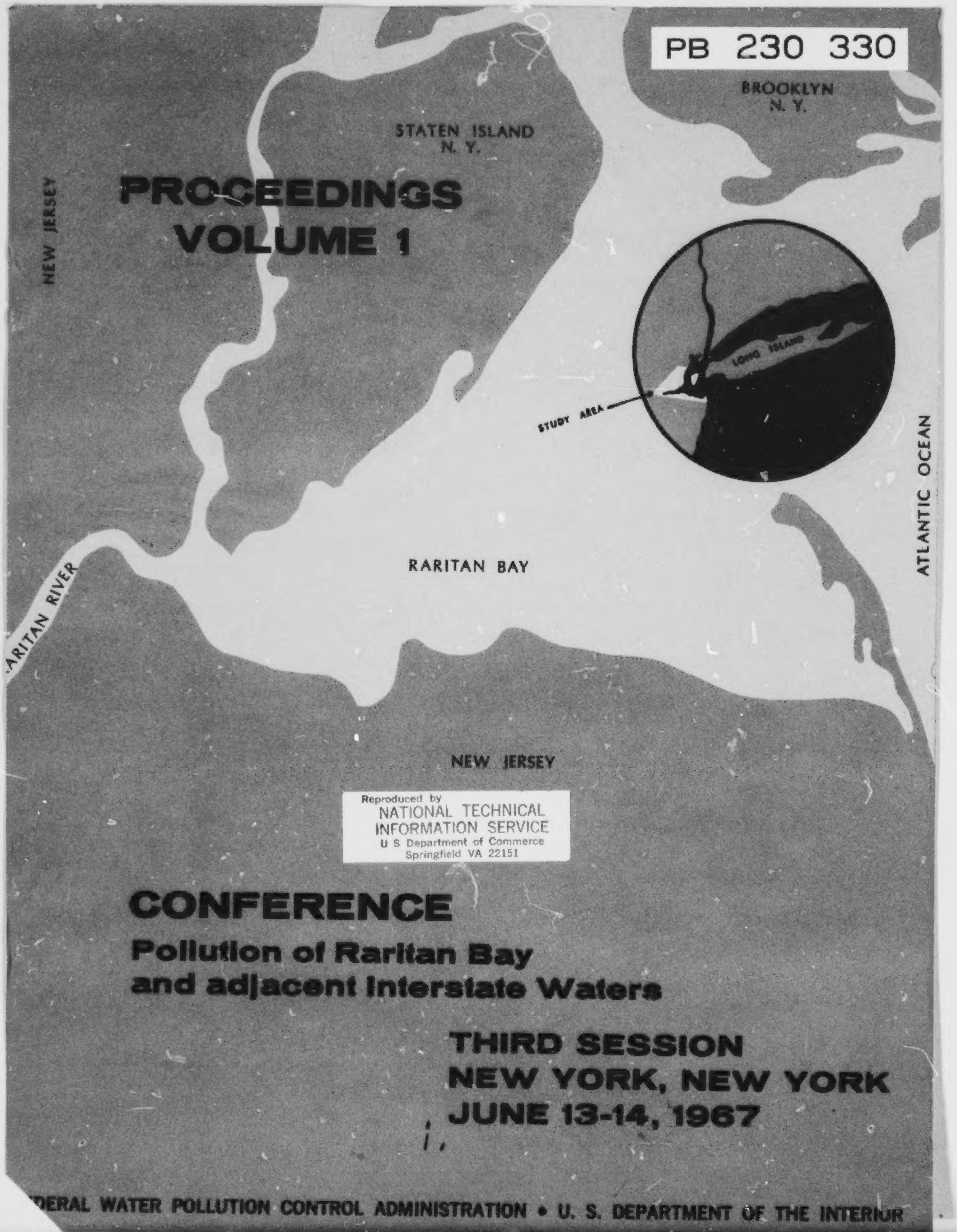
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PROCEEDINGS
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CONFERENCE
Pollution of Raritan Bay and adjacent Interstate Waters

THIRD SESSION
NEW YORK, NEW YORK
JUNE 13-14, 1967

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DERAL WATER POLLUTION CONTROL ADMINISTRATION • U. S. DEPARTMENT OF THE INTERIOR

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Third Session of Conference in the Matter of Pollution of Raritan Bay and Adjacent Interstate Waters, convened at the Waldorf-Astoria Hotel, New York, New York, on Tuesday, June 13, 1967, at 9:30 a.m.

includes statements, discussions and recommendations on: Adequate control measures, bacteriological sampling, disinfection of [illegible] waters, and related information

PRESIDING:

Mr. Murray Stein, Assistant Commissioner for Enforcement, Federal Water Pollution Control Administration, Department of the Interior

CONFEREES:

Lester M. Klashman, Regional Director, Northeast Region, Federal Water Pollution Control Administration, Department of the Interior, Boston, Massachusetts

Robert D. Hennigan, Assistant Commissioner, Division of Pure Water, New York State Department of Health

CONFEREES (Continued):

Dr. Roscoe P. Kandle, Commissioner,
Department of Health, State of New Jersey

Thomas R. Glenn, Director and Chief
Engineer, Interstate Sanitation Commission,
10 Columbus Circle, New York, New York

PARTICIPANTS:

Lester M. Klashman, Conferee and Regional Director, Northeast Region, Federal Water Pollution Control Administration, Department of the Interior, Boston, Massachusetts

Paul DeFalco, Jr., Director, Raritan Bay Project, Federal Water Pollution Control Administration, Department of the Interior, Metuchen, New Jersey

Kenneth H. Walker, Deputy Director, Raritan Bay Project, Federal Water Pollution Control Administration, Department of the Interior, Metuchen, New Jersey

Mark Abelson, Regional Coordinator, United States Department of the Interior, Boston, Massachusetts

Richard E. Griffith, Northeastern Regional Director of Bureau of Sports Fisheries and Wildlife, Department of the Interior, Boston, Massachusetts

PARTICIPANTS (Continued):

Albert S. Kachic, Assistant Regional Hydrologist, United States Weather Bureau, Eastern Region, Environmental Science Services Administration, Garden City, New York

Hon. Robert F. Kennedy, United States Senator from the State of New York, represented by Carter Burden

Robert D. Hennigan, Conferee and Assistant Commissioner, Division of Pure Water, New York State Department of Health, Albany, New York

Maurice M. Feldman, First Deputy Commissioner, Engineering and Research Development, and Deputy General Manager, Bureau of Water Pollution Control, New York City Department of Public Works, New York, New York

Martin Lang, Director, Bureau of Water Pollution Control, New York City Department of Public Works, New York, New York

David H. Wallace, Chief, Bureau of Marine Fisheries, Division of Fish and Game, New York State Conservation Department, Oakdale, New York

Frederick F. Richardson, Former Mayor, New Brunswick, New Jersey

Charles C. Johnson, Jr., Assistant Commissioner, Environmental Health Services, New York City Health Department, New York, New York

PARTICIPANTS (Continued):

Mrs. Virginia Yuhasz, Recording Secretary, Morgan and Bayview Manor Improvement Association, Morgan, New Jersey

James R. Pfafflin, Representing the Raritan Anti-Pollution Association

Brian A. McAllister, McAllister Brothers, Inc., 17 Battery Place, New York, New York (written statement)

THOSE IN ATTENDANCE:

Mark Abelson, Regional Coordinator, Federal Water Pollution Control Administration, Boston, Massachusetts

R. K. Altreuter, Technical Service Head, Humble Oil & Refining, Linden, New Jersey

H. Mat Adams, Chairman, Middlesex County Sewerage Authority, Sayreville, New Jersev

John Bardzik, Jr., Supervisor, Pitt-Consol Chemical Co., Newark, New Jersey

Quentin R. Bennett, Marine Fisheries Sanitarian, New York State Conservation Department, Oakdale, New York

Donald S. Benson, Public Relations Director, New Jersey State Department of Health, Trenton, New Jersey

Hayse H. Black, Industrial Wastes Consultant, Federal Water Pollution Control Administration, Cincinnati, Ohio

George H. Bookbinder, Executive Vice President, Rand Dev. Corp., New York, New York

Louis P. Booz, City Engineer, Perth Amboy, New Jersey

Ralph H. Bowers, New York, New York

Jack L. Bowling, Process Supt., F.M.C. Corp., Carteret, New Jersey

Powel Brown, Market Dev. Executive, No. American Aviation Inc., Washington, D. C.

THOSE IN ATTENDANCE (Continued):

Thomas J. Buchana, Assistant District Chief, U. S. Geological Survey, Trenton, New Jersey

Bernard Buchner, Chief Process Chemist, American Cyanamid Co., Linden, New Jersey

Carter Burden, Administrative Assistant to Senator Kennedy

John B. Burt, Chemical Engineer, General Aniline & Film, Linden, New Jersey

Lloyd Chittenden, Manager, Public Relations, American Cyanamid, Bound Brook, New Jersey

Charles A. Cole, Research Assistant, Rutgers University, New Brunswick, New Jersey

Natale Colosi, Chairman, Interstate Sanitation Commission, New York, New York

William F. Cosulich, Consulting Engineer, Syosset, New York

George Cowherd, Assistant Chief Engineer, Interstate Sanitation Commission, New York, New York

Joseph Cunetta, Department Director, Bureau of Water Pollution Control, New York City, Department of Public Works, New York, New York

Robert V. Day, Senior Engineer, Western Electric, New York, New York

THOSE IN ATTENDANCE (Continued):

Paul DeFalco, Jr., Director, Raritan Bay Project Federal Water Pollution Control Administration, Metuchen, New Jersey

John A. Delistovic, Assistant Advance Projects Engineer, Public Service Electric & Gas Co., Newark, New Jersey

Paul R. De Rienzo, Chief Engineer, Burns & Roe, Inc., Oradell, New Jersey

C. M. Dunnaville, Attorney, Western Electric, New York, New York

Richard Fanning, Sanitary Engineer, W. F. Cosulich Associates, Syosset, New York

Maurice Feldman, Dep. Comm., New York City Department of Public Works, New York, New York

Robert H. Fox, State Design Engineer, Soil Conservation Service, United States Department of Agricultur New Brunswick, New Jersey

A. E. Franzoso, Johns-Manville Corporation, Manville, New Jersey

E. H. Fulton, Assistant Manager-Operations, Paragon Oil Company, Long Island City, New York

D. L. Gallagher, Marketing Manager, Worthington Corporation, Harrison, New Jersey

THOSE IN ATTENDANCE (Continued):

Capt. William Geiger, President, Modern Transportation Company, South Amboy, New Jersey

T. R. Glenn, Jr., Director and Chief Engineer, Interstate Sanitation Commission, New York, New York

Nathan B. Golub, Chief, Division of Maintenance, Northeast Region, National Park Service, Philadelphia, Pennsylvania

Phillip M. Griebel, U. S. Coast Guard, Commander 3rd District, Governors Island, New York

R. G. Griffith, Regional Director, U. S. Fish and Wildlife Service, Boston, Massachusetts

A. Handley, Associate Director, Pure Waters, New York State Department of Health, Albany, New York

John E. Harrison, Regional Engineer, New York State Department of Health, White Plains, New York

Robert D. Hennigan, Assistant Commissioner, New York State Department of Health, Albany, New York

H. Heukelekian, Killam Associates, Millburn, New Jersey

William J. Hughes, Sanitary Engineer, Frederic R. Harris, Inc., New York, New York

Thomas N. Hushower, Sanitary Engineer, U. S. Public Health Service, New York, New York

THOSE IN ATTENDANCE (Continued):

Walter L. Jebens, Technical Division, Humble Oil & Refining Company, Bayonne Plant, Bayonne, New Jersey

Joseph T. Jockel, Technical Service Supervisor, Mobil Oil Company, New York, New York

Charles C. Johnson, Jr., Assistant Commissioner of Health, New York City Health Department, New York, New York

Edward J. Johnson, Attorney, Middlesex County Sewerage Authority, Sayreville, New Jersey

Albert Kachic, Assistant Regional Hydrologist, U. S. Weather Bureau, Garden City, New York

B. K. Kallay, Liaison Engineer, Pennsalt Chemical Corporation, King of Prussia, Pennsylvania

Dr. R. P. Kandle, Commissioner, New Jersey State Health Department, Trenton, New Jersey

Benjamin Karmatz, Delegate, New Jersey Central Council of Sportsmen's Clubs, Highland Park, New Jersey

Lester M. Klashman, Regional Director, Northeast Region, Federal Water Pollution Control Administration, Boston, Massachusetts

Gerald M. Laccere, Assistant Director, New York City Health Department, New York, New York

Martin Lang, Director, Bureau of Water Pollution Control, Department of Public Works, New York, New York

THOSE IN ATTENDANCE (Continued):

W. R. Lang, Meteorologist in Charge, U. S. Weather Bureau, Trenton, New Jersey

John P. Lawler, Quirk, Lawler and Matusky Engineers, New York, New York

H. C. Levin, Secretary, New Jersey Chemical Industry Council, Wayne, New Jersey

Harvey Lieber, 778 East 10th Street, Brooklyn, New York

Joseph W. Ludlum, New Jersey State Chamber of Commerce, Newark, New Jersey

H. J. Lunschel, Special Assistant Supervisor, New York Harbor, U. S. Army Engineers, New York

Albert J. Macchi, General Superintendent of Utilities, American Cyanamid Company, Bound Brook, New Jersey

Ronald Macomber, Aooc Division Field R&D, U. S. Public Health Service, Narragansett, Rhode Island

Brian A. McAl[illegible]r, Port Captain, McAllister Brothers, Inc., New York, New York

Harry W. McDowell, Area Engineer, E. I. DuPont De Nemours, Grasselli Plant, Linden, New Jersey

W. Stanley Meseroll, Jr., Chairman, Raritan Valley Clean Water Association, Highland Park, New Jersey

Charles F. Miles, Jr., Chief, Division of Water Pollution Control, New York City Health Department, New York, New York

PARTICIPANTS (Continued):

Ralph Van Derwerker, Regional Representative of the National Center for Urban and Industrial Health and Regional Program Chief of the Water Supply and Sea Resources Program of the Public Health Service, Department of Health, Education, and Welfare

Frank R. Pagano, New York District Office, Corps of Engineers, New York, New York

Mrs. Elizabeth M. Wallace, Director, Oyster Institute, Sayville, New York

Dr. Roscoe P. Kandle, Conferee and Commissioner, New Jersey State Department of Health, Trenton, New Jersey

Richard J. Sullivan, Director, Division of Clean Air and Water, New Jersey State Department of Health, Trenton, New Jersey

H. Mat Adams, Chairman, Middlesex County Sewerage Authority, Sayreville, New Jersey

Dr. Natale Colosi, Chairman, Interstate Sanitation Commission, New York, New York

Benjamin Karmatz, Delegate, New Jersey Central Council of Sportsmen's Clubs, Highland Park, New Jersey

W. Stanley Meseroll, Jr., Chairman, Raritan Valley Clean Water Association, Highland Park, New Jersey

THOSE IN ATTENDANCE (Continued):

John H. Morris, Engineer Specialist, New Jersey Chem. Ind. Council, Frenchtown, New Jersey

James V. Neely, Jersey Central Power and Light Company, Morristown, New Jersey

James M. Neilland, Monmouth County New Jersey Legislators, Matawn, New Jersey

Jens Nielsen, Staten Island Community Planning Board #3, Staten Island, New York

R. B. Norf, Manager, Mfg. Coord., Enjay Chemical Company, New York, New York

Irwin Novick, Civil Engineer, New York City Department of Public Works, New York, New York

F. R. Pagano, Chief, Basin and Project Planning Branch, New York District, Corps of Engineers, New York, New York

Lincoln Peschiera, Engineer Group Leader, National Lead Company, Titanium Division, South Amboy, New Jersey

James R. Pfafflin, Assistant Professor, Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, New York

Charles M. Pike, Director, Monmouth County Planning Board, Freehold, New Jersey

THOSE IN ATTENDANCE (Continued):

Mrs. Rheta B. Piere, Administrative Officer, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C.

John J. Ploskonka, Engineer, H. T. Carr Assoc., Perth Amboy, New Jersey

Anthony J. Popowski, Middlesex County Sewerage Authority, Sayreville, New Jersey

Ralph Porges, Head, Water Quality Branch, Delaware River Basin Commission, Trenton, New Jersey

Paul Resnick, Project Information Officer, Federal Water Pollution Control Administration, Metuchen, New Jersey

F. F. Richardson, Counsellor at Law, Water Groups of New Brunswick, New Jersey

Anthony R. Ricigliano, Supv. Public Health Engineer, New Jersey Department of Health, Trenton, New Jersey

James C. Riley, Civil Engineer, U. S. Army Engineers, District of New York, New York, New York

E. I. Rumrill, Senior Engineer, E. I. Du Pont De Nemours, Photo Products Department, Parlin, New Jersey

C. A. Rydecker, Commissioner, Middlesex County Sewerage Authority, Sayreville, New Jersey

THOSE IN ATTENDANCE (Continued):

Norma L. Schlissel, Civil Engineer, New York City Department of Public Works, New York, New York

Louis Schwartz, Chief, Plant Des., Bureau of Water Pollution Control, New York City Department of Public Works, New York, New York

Theodore A. Schwartz, Deputy Attorney General of New Jersey, Trenton, New Jersey

Sol Seid, Chief Engineer, Middlesex County Sewerage Authority, Sayreville, New Jersey

David Shedroff, Enforcement Specialist, Federal Water Pollution Control Administration, Southeast Region, Atlanta, Georgia

A. D. Sidio, Sanitary Engineer, Federal Water Pollution Control Administration, R. A. Taft Engineering Center, Cincinnati, Ohio

A. Sitarski, State Gov. Rep., Humble Oil & Refining Company, Linden, New Jersey

A. M. Sobkowicz, Engineer, Enjay Chemical Company, Linden, New Jersey

B. Stengren, 15 Margaret Drive, Plainview, New York

James F. Stomber, President J.F.S. Industires, Inc., Red Bank, New Jersey

THOSE IN ATTENDANCE (Continued):

J. M. Stull, Attorney, E. I. Du Pont De Nemours, Wilmington, Pennsylvania

Richard J. Sullivan, Director or Clean Air and Water, New Jersey Department of Health, Trenton, New Jersey

Henry Stetina, Director, Division of Interstate Compacts and Uniform State Laws, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C.

W. A. Taylor, Pwr, Eng., Texaco Inc., Bayonne, New Jersey

Alfred Tayne, Assistant Chief, Financial Assistant Division, Small Business Administration, New York, New York

R. E. Thurn, Products and Conservation Coordinator, Chevron Oil Company, Perth Amboy, New Jersey

M. V. Trexler, Technical Assistant, F. M. C. Corporation, New York, New York

F. R. Ulrich, Major, Asst. Supv., New York Harbor, U. S. Army Engineers, New York, New York

Ralph Van Derwerker, Regional Representative, U. S. Public Health Service, New York, New York

Kenneth H. Walker, Deputy Director, Raritan Bay Project, Federal Water Pollution Control Administration, Metuchen, New Jersey

THOSE IN ATTENDANCE (Continued):

Elizabeth M. Wallace, Director, Oyster Institute, Sayville, New York

David H. Wallace, New York State Conservation Department, Oakdale, New York

Robert Waller, Techn. Serv. Engineer, E. I. Du Pont De Nemours, Wilmington, Delaware

William H. Wechter, Engineer, Burns & Roe, Oradell, New Jersey

Mitchell Wendell, Counsel, Interstate Sanitation Commission, New York, New York

Charles H. Wentworth, U. S. Public Health Service, U. S. Coast Guard, 3rd CGP, Governors Island, New York

F. O. Williamson, Jr., Project Engineer, E. T. Killam Assoc., Millburn, New Jersey

H. Wolfe, Research Analyst, General Precision Laboratory, Pleasantville, New York

PROCEEDINGS

OPENING STATEMENT
BY
MR. MURRAY STEIN

MR. STEIN: The conference is open.

I understand the air-conditioning has been turned on, and, hopefully, it will get progressively cooler, at least out in the audience.

This third session of the conference in the matter of pollution of the interstate waters of Raritan Bay and adjacent waters is being held under the provisions of Section 10 of the Federal Water Pollution Control Act, as amended.

Under the provisions of the Act, the Secretary of the Interior is authorized to call a conference of this type when, on the basis of reports, surveys, or studies he has reason to believe that pollution of interstate waters subject to abatement under the Act is occurring.

The first session of the conference was held on August 22, 1961. At this session, the conferees agreed that scientific data, taking into account a wide range of factors and technological problems, including health, conservation, water policy and uses, and industrial processes, are urgently needed, and are the critical issue in further control of pollution of Raritan Bay and adjacent waters. As a result of the conferees' recommendation, the Federal water pollution control program, in collaboration with the States of New York and New Jersey and the Interstate Commission, established the Raritan Bay Project to carry out an investigation and to study this data. The second session of the conference was held on May 9, 1963, and the activities of the Project were reviewed. The conferees recommended that the Raritan Bay Project continue and complete the study of Raritan Bay and adjacent waters.

The Project recently completed its study. The findings of the Project and its recommendations for remedial action will be presented today for the consideration of the conferees.

The purpose of the conference is to bring together the State and interstate water pollution control agencies, representatives of the United States Department of the Interior, and other interested parties to review the existing situation, the progress which has been made, to lay a basis for future action by all parties concerned, and to give the States, localities and industries an opportunity to take any indicated remedial action under State and local law.

This conference technique, as has been indicated by the Supreme Court, is one for the best solving of these problems.

We found when we started that the waters of Raritan Bay were very complex indeed. While a considerable amount of pollution control work has been done in rivers, and we have the rivers catalogued fairly well and techniques worked out fairly well, I think we were striking out on relatively new ground when we began working on the waters of Raritan Bay and the estuaries involved.

Considering when we started this in 1961 and the fact that we have completed it now, I don't think the Project was too long. It is just that the work was tremendously complex and we had to grapple with the work step by step.

As long ago as 1921, the Supreme Court said in the case of New York vs. New Jersey -- and I think there is no more prophetic statement than this that they made forty years before we started -- as follows:

> "We cannot withhold the suggestion, inspired by the consideration of this case, that

> "the grave problem of sewage disposal by the large and growing population living on the shores of New York Bay is one more readily to be most wisely solved by cooperative study and by conference and mutual concession on the part of representatives of the States so vitally interested in it than by proceedings in any court however constituted."

I think that our experience with this problem and with the study has indicated that the Supreme Court knew what it was talking about in 1921, even though it took us quite a while to follow its precepts.

As specified in Section 10 of the Federal Water Pollution Control Act, the Secretary of the Interior has notified the official State and interstate water pollution control agencies of this conference. This conference is between the official State and interstate agencies and the Federal Water Pollution Control Administration of the United States Department of the Interior.

The State of New York has designated as its conferee for this conference Mr. Robert Hennigan. The State of New Jersey will be represented by Dr. Roscoe Kandle, and the representative of the Interstate Sanitation Commission is Mr. Thomas Glenn. Mr. Lester Klashman, who is Director for this region of the Federal Water Pollution Control Administration of the Department of the Interior, with headquarters in Boston, Massachusetts, has been designated as conferee for the Federal Government.

My name is Murray Stein. I am from headquarters in Washington of the Department of the Interior and the representative of Secretary Udall.

The parties to this conference are the representatives of the New York State Department of Health, the New Jersey State Department of Health, the Interstate Sanitation Commission and the United States Department of the Interior. Participation in this conference will be open to representatives and invitees of these agencies and such persons as inform me that they wish to present statements. However, only the representatives of the States of New York and New Jersey, the Interstate Sanitation Commission, and the United States Department of the Interior constitute the conferees.

Both the State and Federal governments have responsibilities in dealing with water pollution control problems. The Federal Water Pollution Contract Act declares that the States have primary rights and responsibilities for taking action to abate pollution. Consistent with this, we are charged by law to encourage the States in these activities.

At the same time, the Secretary of the Interior is also charged by law with specific responsibilities in the field of water pollution control in connection with the navigable and interstate waters. The Federal Water Pollution Control Act provides that pollution of interstate or navigable waters, whether the matter causing or contributing to the pollution is discharged directly into such waters, or reaches such waters after discharge into a tributary, which endangers the health or welfare of any persons, shall be subject to abatement.

We expect that this conference will be useful in providing a clear picture of the problem, delineating the progress which has already been accomplished, and in indicating what needs to be done to correct the pollution problems in these interstate waters.

Now a word about the procedure governing the conduct of the conference. The conferees will be called upon to make statements. The conferees, in addition, may call upon participants whom they have invited to the conference to make statements.

I would suggest that anyone wishing to make a statement get in touch with either Dr. Kandle or Mr. Hennigan from New Jersey or New York, and arrange with them to make the statement, because we would prefer to have the

States manage their own time.

At the conclusion of the statements, the conferees, the people at the table here, or myself, may ask some questions or comment. There will be no questions or comments from the floor. We would suggest you hold that until you are given an opportunity to make a statement. Everyone will be permitted to make a full statement in his own manner, as long as the material is relevant.

At the end of all the statements we will have a discussion among the conferees and try to arrive at a basis of agreement on the facts of the situation. Then we will make an announcement of the conclusions of the conferees.

Under the Federal law, the Secretary of the Interior is required at the conclusion of the conference to prepare a summary of it which will be sent to the conferees. The summary, according to law, must include the following points:

1. Occurrence of pollution of interstate waters subject to abatement under the Federal Act;
2. Adequacy of measures taken toward abatement of pollution; and
3. Nature of delays, if any, being encountered in abating the pollution.

Opening Statement - Mr. Stein

The Secretary is also required to make recommendations for remedial action if such recommendations are indicated.

A record and verbatim transcript of the conference is being made by Mr. Al Zimmer. This is made for the purpose of aiding us in preparing a summary, and also providing a complete record of what is said here.

We will make copies of the summary and transcript available to the official water pollution control agencies of New York and New Jersey and the Interstate Sanitation Commission.

We have found that, generally, for the purpose of maintaining relationships within the States that the people who wish summaries and transcripts should request them through their State or interstate agency, rather than come directly to the Federal Government. The reason for this is that when the conference has been concluded we would prefer people who are interested in the problem to follow their normal relations in dealing with the State or interstate agencies, rather than the Federal Government, on these matters. This has worked successfully in the past and we will be most happy to make this material available for distribution.

There is one other point: Any exhibits reproduced and any charts reproduced in the record will be in black and white, and will not be in color. It is therefore suggested that if you come up and talk about an exhibit, if your remarks are to be meaningful in the transcript, that you not refer to "the green area over there" and "the red area over there," but that you use other descriptive words that will have meaning when the transcript is ready.

I would suggest that all speakers and participants other than the conferees making statements come to the lectern and identify themselves for the purposes of the record.

With that, we will call on the Federal Conferee, Mr. Lester Klashman.

Mr. Klashman.

STATEMENT OF LESTER M. KLASHMAN, CONFEREE AND REGIONAL DIRECTOR, NORTHEAST REGION, FEDERAL WATER POLLUTION CONTROL ADMINISTRATION, DEPARTMENT OF THE INTERIOR, BOSTON, MASSACHUSETTS

MR. KLASHMAN: Thank you very much, Mr. Stein.

It is very nice to be back here in New York after five years out of your Northeast Region.

The Federal presentation for the Raritan Bay Project will be made by Mr. Paul DeFalco, and this will be followed by presentations by several of the other Federal agencies.

For those Federal agencies who have not told Mrs. Daly or Mrs. Eleanor Patten, who are the two young ladies out in the hallway on your way in, that you plan to make a statement, I would appreciate it if you would confirm this with them, if you do plan to make one.

With that, we will start with Mr. Paul DeFalco, who is the Director of the Raritan Bay Project.

STATEMENT OF PAUL DeFALCO, JR., DIRECTOR, RARITAN BAY PROJECT, FEDERAL WATER POLLUTION CONTROL ADMINISTRATION, DEPARTMENT OF THE INTERIOR, METUCHEN, NEW JERSEY

MR. DE FALCO: Conferees and Ladies and Gentlemen:

Paul DeFalco

My name is Paul DeFalco, Jr., and I am Director of the Raritan Bay Project, Deputy Regional Director of the Northeast Region, Federal Water Pollution Control Administration.

I would like at this point to ask the conferees to have the entire report entered into the record of the conference. I am going to present an abstracted version of this with the assistance of Mr. Kenneth Walker.

MR. STEIN: Let me see that, please.

Do you want the whole thing in?

MR. DE FALCO: Yes, sir.

MR. STEIN: Without objection, this will be done.

MR. DE FALCO: Thank you.

REPORT
for
THE CONFERENCE ON POLLUTION OF RARITAN BAY AND ADJACENT INTERSTATE WATERS

THIRD SESSION

VOLUME I-PROJECT STUDIES AND RESULTS

Paul DeFalco

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHEAST REGION - RARITAN BAY PROJECT
METUCHEN, N.J.
May 1967

INTRODUCTION

Purpose and Scope

In 1961 the Surgeon General of the Public Health Service, under the provisions of the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.), called a conference on the pollution of the interstate waters of Raritan Bay and adjacent waters. As a result of this conference the Public Health Service established the Raritan Bay Project to undertake a study of these waters to provide scientific data on which further pollution control programs could be established.

This report presents results of Project studies which included the following activities:

1. Intensive bacteriological sampling of

Paul DeFalco

Raritan Bay and shoreline, Arthur Kill, Kill Van Kull, Upper Bay, Raritan River and wastewater treatment plants discharging to study area waters.

2. Intensive chemical sampling of these same waters and wastewater treatment plants to determine dissolved oxygen concentrations, biochemical oxygen demands, chemical oxygen demands and nutrient levels -- nitrites, nitrates and phosphates.

3. Intensive biological sampling in these waters to determine biological communities of phytoplankton, zooplankton and benthic organisms as they are related to pollution.

4. Current and dispersion studies to trace water movements in Raritan Bay and movements from the Arthur Kill, Raritan River and the Narrows into the Bay.

5. Detailed wastewater treatment plant surveys and sampling programs to determine operating efficiency. Surveys included an evaluation of the condition of equipment, effectiveness of operation and maintenance, and the qualifications of plant operators.

6. Detailed surveys of industrial operations including a review of data collected by other agencies, plant visitations, and sampling programs to evaluate treatment efficiencies and measure contaminants discharged.

Paul DeFalco

7. Survey of commercial fishing and the quality and quantity of shellfish in Raritan Bay to determine the present condition of these industries and their future potential.

8. Investigation of the present and potential use of the study waters for recreational bathing, boating, and fishing.

9. Study of the pollution effects of commercial shipping and recreational boating in the area.

10. Establishment of a series of automatic water quality monitoring stations to provide a measure of the quality of the waters entering Raritan Bay.

11. Review of field and laboratory data to determine the effects of stormwater overflows on present water quality.

12. Study to determine the effectiveness of chlorination of wastewater treatment plant effluents in reducing bacteria populations in Raritan Bay.

13. Determination of the municipal and industrial wastes load discharged to Arthur Kill.

14. Investigation of the geology of Raritan Bay to provide further data on water movement in the study area.

15. Study to determine the absence or

presence of known pathogenic, or disease-causing bacteria, in Raritan Bay waters and in shellfish taken from various locations throughout the estuary.

Project History

The Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.), provides that pollution of interstate waters which endangers the health or welfare of any person is subject to abatement under procedures described in Section 10 (33 U.S.C. 466 g) of the Act.

The first step of this procedure is the calling of a conference which brings together State and interstate water pollution control agencies, the Public Health Service and other interested parties having jurisdiction in the area. The purposesof such a conference are to review the existing situation, to lay a basis for future action by all parties concerned, and to give States, interstate agencies, localities and industries an opportunity to take any indicated remedial action under State and local law.

On the basis of reports, surveys and studies the Surgeon General of the Public Health Service, having reason to believe that pollution of the interstate waters

Paul DeFalco

of Raritan Bay and adjacent waters -- caused by discharges of untreated and inadequately treated sewage and industrial wastes by municipalities and industries in New Jersey and New York -- was endangering the health and welfare of persons in these two States, called a conference on August 22, 1961. Conferees present represented the New Jersey State Health Department, New York State Department of Health, Interstate Sanitation Commission and the Public Health Service.

At the first session, conferees unanimously agreed to the following conclusions and recommendations:

> "1. The Raritan Bay and adjacent waters which are the subject of the conference are interstate waters within the meaning of the Federal Water Pollution Control Act.
>
> "2. There is pollution of these waters.
>
> "3. Scientific data, taking into account a wide range of factors and technological problems, including health, conservation, water policy and uses, and industrial processes are urgently needed, and are the critical issue in further control of these waters.
>
> "4. The Public Health Service in collaboration with the New Jersey State Health Department, the

"New York State Department of Health, and the Interstate Sanitation Commission, will undertake an investigation and study of these waters to accumulate these data.

"5. Cognizance is taken of the programs and the administrative machinery of the agencies of the State of New York and the State of New Jersey, and the Interstate Sanitation Commission to control pollution of these waters.

"6. There has been, and continues to be, progress under plan in abatement of pollution of these waters.

"7. The conferees welcome and appreciate the interest, support and collaboration of the Public Health Service in the collective efforts to preserve the Raritan Bay and particularly in solving the scientific problems.

"8. The conferees are willing to report to the Public Health Service at appropriate intervals; the Public Health Service will report to the other conferees periodically.

"9. The conference will be reconvened on the call of the Chairman one year from the present date in order to evaluate the progress made by the study

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"and investigation and to receive the recommendations of the conferees as to further action."

In accordance with the recommendations of the first conference, the Public Health Service, Division of Water Supply and Pollution Control, secured, equipped and staffed a laboratory at Raritan Depot, Edison, New Jersey, to conduct water quality investigations. The objective of the Project was to develop the scientific data necessary for the conferees to establish an effective program for the abatement and control of pollution in the study area, which was defined to include Lower, Sandy Hook and Raritan Bays, a portion of the Narrows, Arthur Kill, the tidal reach of the Raritan River and other smaller tributaries to the above named waterways.

First phase of Project activities was the assembling of a staff and a review of existing data. Based upon this review a sampling program was designed which would permit an evaluation of the variations in water quality and long-term trends. The program was initiated in August of 1962 and consisted of a 13-month sampling program of Raritan Bay, Arthur Kill and the municipal wastewater treatment plants discharging to these waters. Weekly samples were taken at each of the sampling stations within Raritan Bay and Arthur Kill. Simultaneously, samples were collected of the effluents from each of the major municipal treatment plants discharging to the Bay to permit an assessment of the relationship between waste load and water quality. In May 1963 the Project reported to the second session of the Conference in the Matter of Pollution of Interstate Waters of Raritan Bay and Adjacent Waters (New York-New Jersey). Presented at that session were all data generated by the Project from its inception to December 31, 1962. Among the activities initiated by the Project through that reporting date were:

1. Intensive bacteriological sampling program of Raritan Bay and shoreline, entrant waters, and wastewater treatment plants discharging to the Bay to determine bacterial densities.

2. Series of dissolved oxygen tests in Raritan Bay, and biochemical oxygen demand tests of wastewater treatment plant effluents.

3. Current and dispersion studies to trace water movements in Raritan Bay and movements from the Arthur Kill into the estuary.

4. Biological investigation to define the area of biological concern for purposes of further studies.

Conferees at the second session agreed to the following conclusions and recommendations:

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"1. The States of New Jersey and New York and the Interstate Sanitation Commission have active and effective programs for the control and abatement of pollution of the waters of Raritan Bay and adjacent waters as evidenced by:

"a. With respect to waters other than those originating in the Arthur Kill and coming through the Narrows, the New Jersey communities have been steadily improving treatment since the 1940's. At the present time, all domestic waste from New Jersey discharging into the Hudson River and upper New York Bay area have been intercepted for treatment except for a portion of Weehawken and Union City, where the construction of needed facilities is nearing completion. On the New York side, New York City, pursuant to a consent order of the Interstate Sanitation Commission dating from 1957 has been engaged in a large program of construction. The Hunts Point and Coney Island projects have been completed. Under construction are the pollution control projects of Newton Creek and Jamaica Bay. Scheduled for early construction,

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"pursuant to the consent order, are projects at Red Hook, Port Richmond, North River and Ward's Island. On these projects as well as those mentioned subsequently the work is done pursuant to the approval of plans and specifications by the New Jersey and New York State Health Departments.

"b. Entrant waters from the Raritan River were improved by completion in 1958 of the Middlesex County Sewerage Authority Treatment Plant. The New Jersey Health Department and the Authority have a continuing program on further abatement of pollution of the Raritan River.

"c. In the Arthur Kill intensive research and investigations by New York, New Jersey and the Interstate Sanitation Commission have been underway since 1957. As a result information has recently become available which has formed the basis for the issuance of eight orders by the State of New Jersey as follows: Elizabeth Joint Meeting, Rahway Valley Sewerage Authority, Linden-Roselle Sewerage Authority, Borough of Carteret, Woodbridge Township,

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"Humble Oil and Refining Company, American Cyanamid, General Aniline and Film Company; and three by New York authorities as follows: Procter and Gamble, Nassau Smelting and Refining Company and the Willowbrook State School.

"d. In Raritan Bay, pursuant to an administrative order and a timetable agreement with the Attorney General of the State of New Jersey, construction of needed works at Keyport was already underway prior to the first session of this conference, and was completed in 1962. At Atlantic Highlands, Highlands, Keansburg, Union Beach, Borough of Matawan and two industrial installations, steps of either engineering or a legal nature are in progress. The Borough of Highlands is installing an automatic chlorine residual analyzer and recorder with an alarm system and is also planning to repair the outfall line which would take the effluent from Raritan Bay and discharge it to the Atlantic Ocean. The borough of Atlantic Highlands has hired an engineer to prepare preliminary studies to enarlge the present facilities by 50 percent and has applied for

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"Housing and Home Finance Agency planning funds. In addition the Borough is planning to install a chlorine residual analyzer and recorder with an alarm system. The Borough of Keansburg has planned for additions and alterations to this plant and they have been approved by the State Department of Health. The Borough plans to advertise for bids soon. In Union Beach a certificate of necessity has been issued to allow this community to exceed bonded indebtedness limitations. Preliminary plans have been approved by the State Health Department for a sewage system and treatment plant. The Borough of Matawan has completed construction of a new plant which was placed in operation during the last week of April 1963. Construction of a new treatment plant by the Madison Township Sewerage Authority is nearing completion with a scheduled completion date of May 1963. Plans for proposed expansion to increase the capacity of the Middlesex County Sewerage Authority plant are scheduled to be completed by the latter part of 1963. The International Flavor and Fragrances Company

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"hired an industrial waste engineer to develop treatment facilities. A feasibility report has been furnished. Pollution sources of the B. Zura Chemical Company have been eliminated by the closing of the plant.

"For the New York waters concerned, the State Department of Health has completed classification studies and report covering the subject waters. Arrangements are now being made for public classification hearings to be held in New York City during the months of June or July. Actual classification will be made by the Water Resources Commission for New York State. The classifications of the Interstate Sanitation Commission for these waters have been in force for over twenty years.

"2. The Public Health Service, in collaboration with the New Jersey State Department of Health, the New York State Department of Health, and the Interstate Sanitation Commission will continue and complete the investigation and study of the Raritan Bay and adjacent waters in accordance with the recommendations of the conferees at the first session of the conference held on August 22, 1961."

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In accordance with recommendations of the second session, the Public Health Service continued its studies to define the type of pollution problems existing in the interstate waters of Raritan Bay and adjacent waters. The already established intensive study program, which involved determination of specific pollutants and their concentration, and methods of securing the best possible water quality, continued through September 1963. At the conclusion of this sampling period the Project adopted a surveillance program consisting of monthly samplings at selected stations throughout the study area as well as at wastewater treatment plant discharges. The change to a surveillance operation was accompanied by the initiation of Project studies in special subject areas found necessary as a result of the previous investigations. Such studies, initiated in September 1963 and continued through January 1966, were to evaluate and ascertain information on such items as water movement through the Bay; the presence or absence of specific pathogenic organisms in Bay waters and in shellfish; an evaluation of the shellfish quality and probable harvest value; surveys of industrial wastes discharges; and surveys of various water uses and their effects upon water quality, including studies of commercial and recreational fishing, commercial navigation, recreational boating and bathing.

STUDY AREA

General Description

The Project study area encompasses three major bodies of water, all located within the New York metropolitan area. The estuary, collectively referred to in this report as Raritan Bay, is further divided into three general areas -- Raritan Bay in the western and southern area, Lower Bay in the north and Sandy Hook Bay in the southeast. The estuary is triangular in shape and opens eastward to the Atlantic Ocean. It is divided roughly into two equal portions by the New York-New Jersey State line as shown in Figure 1.

The second major body of water included in the Project study area is the Arthur Kill, a tidal strait which connects the western end of Raritan Bay estuary with Newark and Upper Bays via the Kill Van Kull in the north See Figure 1). The Project also investigated a reach of the Raritan River, the major fresh water tributary to the bay, from its mouth to the junction of the Millstone River in Manville, New Jersey (See Figure 2).

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This report, for purposes of presentation and evaluation of data, assumes the mouth of the Raritan River as being located at the New Jersey Central Railroad bridge between Perth Amboy and South Amboy, New Jersey; and the southern limit of the Arthur Kill as being the Outerbridge Crossing between Perth Amboy, New Jersey, and Staten Island, New York.

Physical Features

Raritan Bay and Arthur Kill collectively have a water surface area of 93 square miles and a water volume of 38 billion cubic feet, both at low water. Table I presents additional physical measurements of the Bay and Kill. The shorelines of Raritan Bay, amounting to 43 miles exclusive of the Arthur Kill, are relatively straight. Sea cliffs and wide beaches, as well as tidal marshes, indicate the bay has reached early maturity in the cycle of shoreline development along submergent coasts.

The estuary is relatively shallow, with a mean depth of less than 15 feet, excluding the Arthur Kill. The floor of Raritan Bay slopes fairly uniformly and gently toward the center where the maximum depth is about 30 feet, excluding the commercial shipping channels which have

TABLE I

PHYSICAL DATA FOR RARITAN AND LOWER BAYS AND ARTHUR KILL

Area	Volume (Billion cubic feet)		Surface Area (Square Miles)	Mean Depth (Feet)	Shore Line (Miles)		
	(Low Water)	(High Water*)	(Low Water)	(Vol. ÷ Surf. Area)	Staten Is.	New Jersey	Total
Raritan Bay	10.4	14.8	31.82	11.75	11.18	13.00	24.18
Lower Bay (Inc. Sandy Hook Bay)	25.4	33.2	56.39	16.18	5.98	13.00	18.98
Raritan, Lower and Sandy Hook Bays combined	35.8	48.1	88.24	14.55	17.16	26.00	43.16
Arthur Kill	2.23	2.83	4.36	18.38	17.78	18.59	36.37
Total Study Area **	38.03	50.93	92.60	-	34.94	44.59	79.53

*Taking mean tidal range as 5 feet

**Excluding Raritan River

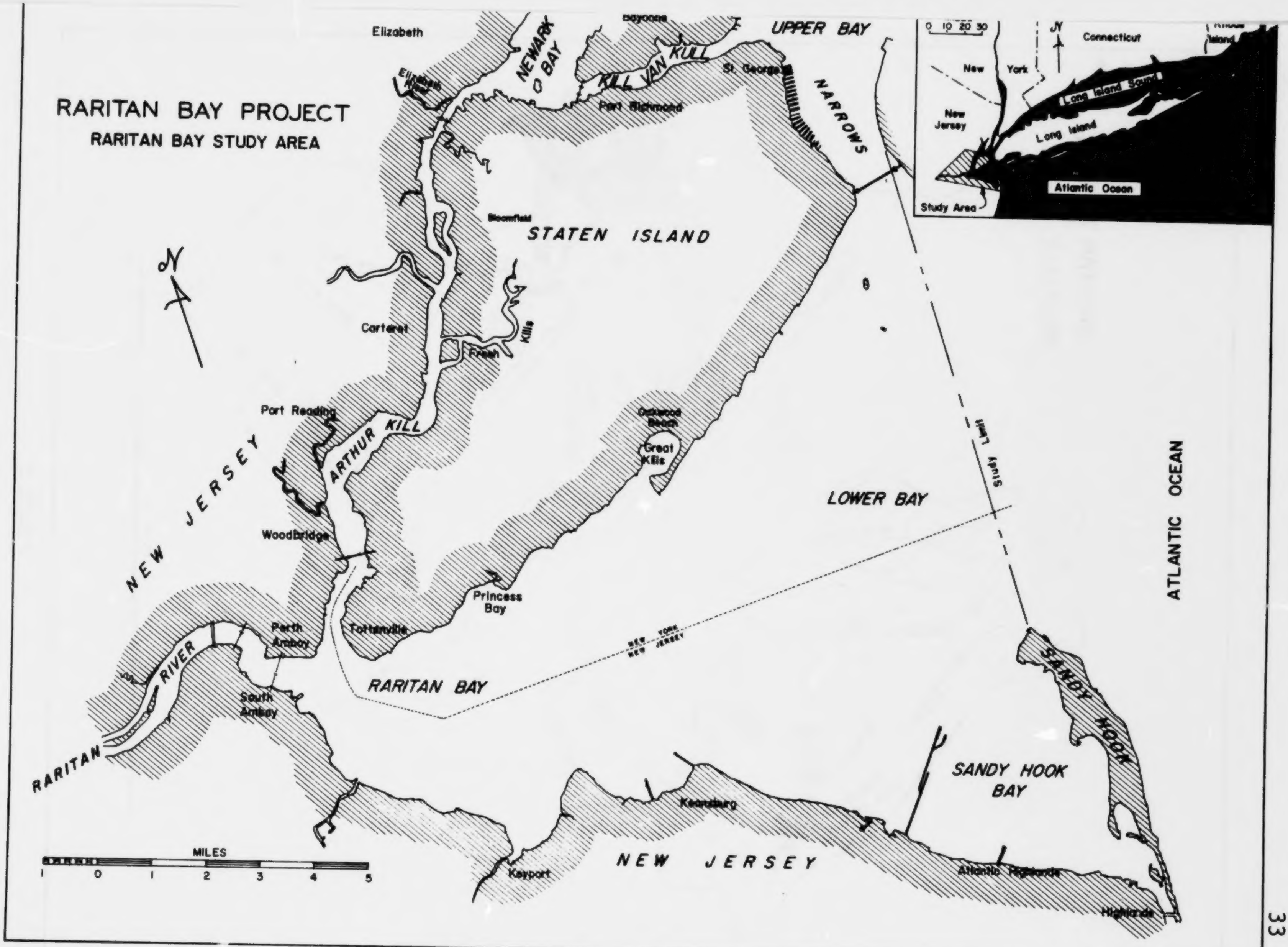
RARITAN BAY PROJECT
RARITAN BAY STUDY AREA
Elizabeth
Elizabeth River
NEWARK BAY
Bayonne
KILL VAN KULL
UPPER BAY
St. George
Port Richmond
NARROWS
Bloomfield
STATEN ISLAND
N
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
Oakwood Beach
Great Kills
NEW JERSEY
Woodbridge
LOWER BAY
Study Limit
ATLANTIC OCEAN
Princess Bay
Tottenville
Perth Amboy
NEW YORK
NEW JERSEY
RARITAN BAY
RARITAN RIVER
South Amboy
SANDY HOOK
SANDY HOOK BAY
Keansburg
MILES
1 0 1 2 3 4 5
Keyport
NEW JERSEY
Atlantic Highlands
Highlands
0 10 20 30
N
New York
Connecticut
Rhode Island
Long Island Sound
New Jersey
Long Island
Atlantic Ocean
Study Area

FIGURE I

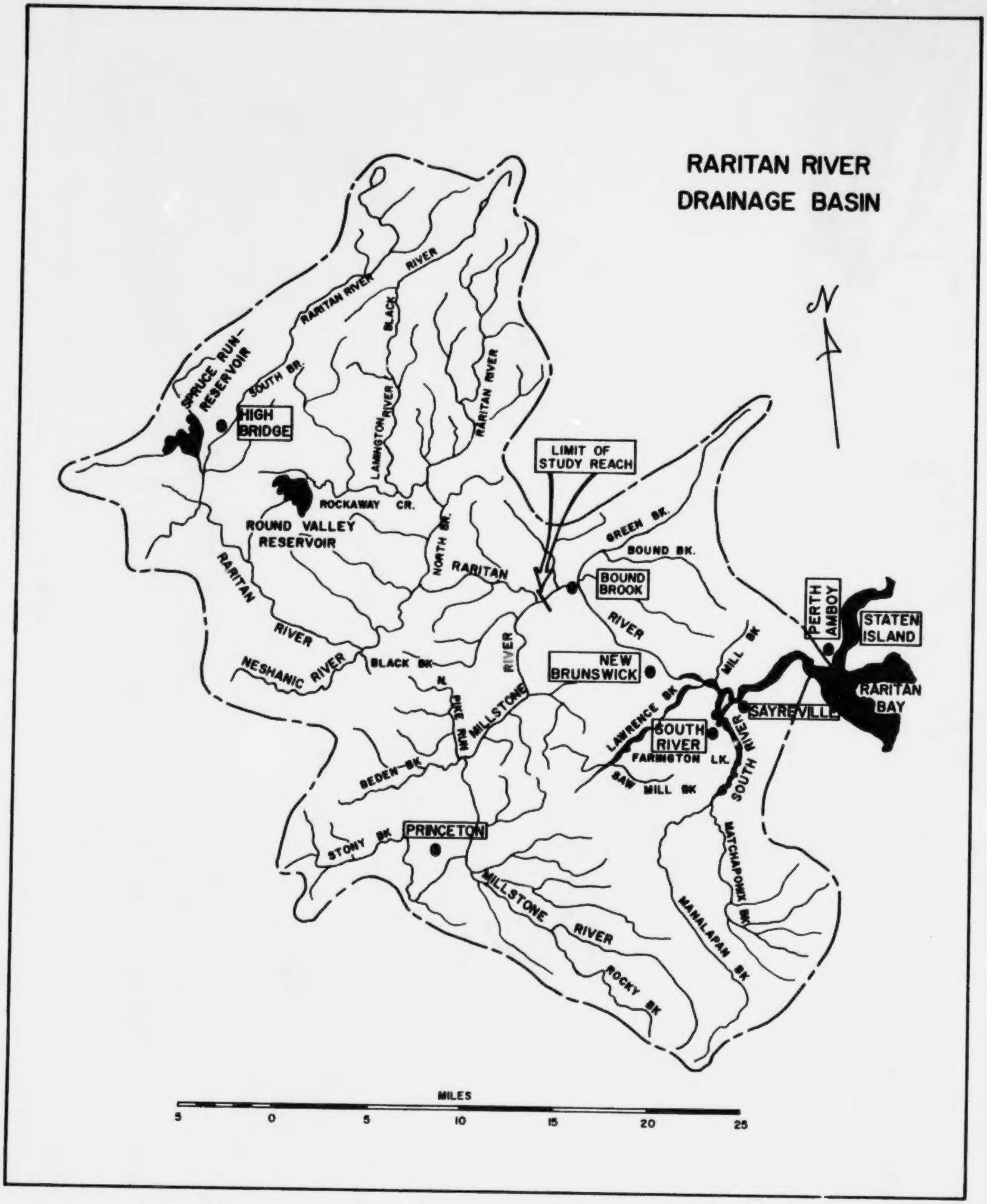
RARITAN RIVER
DRAINAGE BASIN
N
SPRUCE RUN RESERVOIR
HIGH BRIDGE
SOUTH BR.
RARITAN RIVER
RIVER
BLACK
LAMINGTON RIVER
RARITAN RIVER
ROCKAWAY CR.
ROUND VALLEY RESERVOIR
NORTH BR.
RARITAN
LIMIT OF STUDY REACH
GREEN BK.
BOUND BK.
BOUND BROOK
RIVER
RARITAN
RIVER
NESHANIC RIVER
BLACK BK
N.
RIVER
NEW BRUNSWICK
PIKE RUN
MILLSTONE
LAWRENCE BK
MILL BK
PERTH AMBOY
STATEN ISLAND
RARITAN BAY
SAYREVILLE
SOUTH RIVER
FARINGTON LK.
SAW MILL BK
SOUTH RIVER
BEDEN BK
STONY BK
PRINCETON
MATCHAPONIX BK
MILLSTONE
RIVER
MANALAPAN BK
ROCKY BK
MILES
5
0
5
10
15
20
25

FIGURE 2

depths to 40 feet. The floor of the estuary consists of sands and silts, comprising four separate sediment bodies.

The Arthur Kill has a shoreline of 36 miles in New York and New Jersey and a calculated mean depth of 18 feet. The Kill is characterized by a narrow commercial shipping channel of 35 feet depth throughout is entire length.

The reach of the Raritan River included in the study area extends a distance of 21 miles from its mouth at Raritan Bay to the junction of the Millstone River. Above this confluence the Raritan River is a potable water supply. Fieldville Dam, 17 miles above the mouth, creates a small pool extending upstream of this point, and is the upstream limit of tidal influence. The 12 miles of waterway from Raritan Bay to New Brunswick, New Jersey, is navigable, with channel depths ranging from 25 feet below low sea level at Perth Amboy to nine feet below low sea level at New Brunswick.

Climatology

The climate of the study area, as characterized by New York City, is temperate with an average annual of 52°F. January and February, the coldest months, have a mean temperature of 31°F and July, the warmest month, has a mean of 73°F. Water temperatures generally follow a similar pattern, ranging from 0°C to 26°C. During summer months both air and water temperatures are suitable for a variety of water-based recreation, including bathing.

The average annual precipitation in the study area is approximately 42 inches, with heavier rainfall generally associated with the summer months. Precipitation during the Project study was generally below average as the entire northeastern area of the United States experienced severe drought conditions. Table II presents total precipitation and departures from normal for a number of weather stations in close proximity to Raritan Bay and Arthur Kill.

Prevailing winds in the study area are generally from the north and west. At Sandy Hook, New Jersey, almost 20 percent of the total wind duration is from the northwest; winds from the north and northeast each occur slightly more than 15 percent of the time.

Tides throughout the estuary are semi-diurnal and have a mean range varying from 4.3 feet at Fort Wadsworth at the Narrows to 5.3 feet at Tottenville, Staten Island, New York. The spring range at these locations is 5.2 and 6.4 feet respectively.

TABLE II[1]

TOTAL ANNUAL PRECIPITATION AND DEPARTURES FROM NORMAL [2]

	1962		1963		1964		1965[3]	
Station	Prec.	Dep.	Prec.	Dep.	Prec.	Dep.	Prec.	Dep.
Flemington, N.J.	43.91	-1.40	36.23	-9.08	34.50	-10.81	27.11	
Freehold, N.J.	40.94	-5.09	33.89	-12.14	33.83	-12.20	28.80	
Long Valley, N.J.	44.95	-3.95	32.88	-16.02	26.43	-22.47	-	
New Brunswick, N.J.	40.27	-3.71	33.16	-10.82	34.62	- 9.36	23.75	
Plainfield, N.J.	45.27	-3.02	35.38	-12.91	39.93	- 8.36	28.69	
New Monmouth, N.J.	49.50	NA[4]	38.60	NA	-	NA	-	
Rahway, N.J.	37.01	NA	28.48	NA	36.62	NA	22.42	
Westerleigh, N.Y. (Staten Island)	44.77	NA	34.23	NA	37.66	NA	22.64	

1/ Source: U.S. Weather Bureau

2/ Normal rainfall based on period 1951-1960

3/ Incomplete - records for 10 months only

4/ NA: Data not available

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Hydrology

Raritan Bay and Arthur Kill receive water from adjacent saline bodies including the Atlantic Ocean, Upper and Newark Bays, and Kill Van Kull. As shown in Table I, the bay and kill have a combined volume at low water of 38 billion cubic feet, of which the kill comprises less than 6 percent. Volume at high water is estimated as 51 billion cubic feet, or 34 percent more than low water. Chloride concentration in the estuary ranges from 13,000 to 15,000 mg/l, compared to a normal value for ocean water of 20,000 mg/l. Hence, the estuary is roughly two-thirds ocean water, with the balance representing fresh water inflow to the estuary.

The major fresh water input originates in the Hudson River Basin, which discharges through Upper Bay in the Narrows into the easterly area of Raritan Bay. Ayers(1) in 1951 calculated that a net discharge of 6.0 billion cubic feet per tide leaves the Upper Bay system and enters Lower Bay through the Narrows. On the basis of salinity measurements Ayers further calculated that 0.7 billion cubic feet of fresh water moved through the Narrows into Lower Bay on each tide. Hence, the discharge through the Narrows must be recognized as a major source of water into Raritan Bay.

---

(1) Cornell University Contract N6 onr 264, Task 15, Status Report #1

The natural fresh water drainage area of the bay and Arthur Kill is approximately 1,300 square miles, including the basins of a number of tributary streams. The major tributaries are the Raritan and Shrewsbury Rivers, which drain directly to the bay, and the Elizabeth and Rahway Rivers, which flow to the Arthur Kill. Table III presents data on USGS gauging stations on these streams, the calculated average runoff rate for each, and the total average fresh water discharge.

Total average fresh water runoff from these sources to Raritan Bay and Arthur Kill amounts to 2,000 cfs., more than 80 percent of which is provided by the Raritan River. Figure 2A presents a frequency curve for discharge at the Raritan River mouth extrapolated from the USGS 23-year record at Bound Brook, New Jersey.

During Project studies precipitation and stream runoff were below average. Examination of Geological Survey records for the water years October 1960 through September 1963 for the Raritan River indicates that the frequency distribution of runoff during this period was approximately 10 percent below normal. Hence, the severe drought which developed throughout the Northeast during the latter phases of the study resulted in a reduction of fresh water inflow to the estuary and kill below the average

TABLE III

SUMMARY OF USGS STREAM GAGING STATION RECORDS, RARITAN BAY STUDY AREA STREAMS

Gaging Station Location	Drainage Area, mi^2	Average Discharge, cfs	Average Runoff Rate, cfsm
Raritan River Basin			
Raritan River, Bound Brook, N.J.	779	1,220	1.57
Green Brook, Plainfield,N.J.	9.8	12.1	1.24
Lawrence Brook, Farrington Dam, N.J.	34.4	38.5	1.12
South River, Old Bridge, N.J.	94.6	137	1.45
TOTALS	917.8	1407.6	
Extrapolated total average discharge:	1,072	1,650	
Arthur Kill Drainage Area			
Elizabeth River, Elizabeth, N.J.	20.2	23.8	1.18
Rahway River, Rahway, N.J.	40.9	44.8	1.10
Robinson's Branch, Rahway River, Rahway, N.J.	21.6	23.5	1.09
TOTALS	82.7	92.1	
Extrapolated total average discharge:		136	
Extrapolated total average discharge for total Arthur Kill drainage area:		160	

TABLE III (Cont'd)

SUMMARY OF USGS STREAM GAGING STATION RECORDS,
RARITAN BAY STUDY AREA STREAMS

Gaging Station Location	Drainage Area, mi^2	Average Discharge, cfs	Average Runoff Rate, cfsm
Navesink-Shrewsbury River Basin			
Swimming River (head of Navesink River) near Red Bank, N.J.	48.5	77.2	1.59
New Jersey Shore Drainage Area	69	-	1.50*
Extrapolated total average discharge:		110	
Staten Island Shore Drainage Area	24	-	1.10*
Extrapolated total average discharge:		25	

* Estimated

PROBABILITY PLOT OF EXTRAPOLATED
DAILY DISCHARGE DATA FOR RARITAN
RIVER AT ENTRANCE TO RARITAN BAY
1904-08,45-58,60-63
DRAINAGE AREA 1072 SQ. MILES

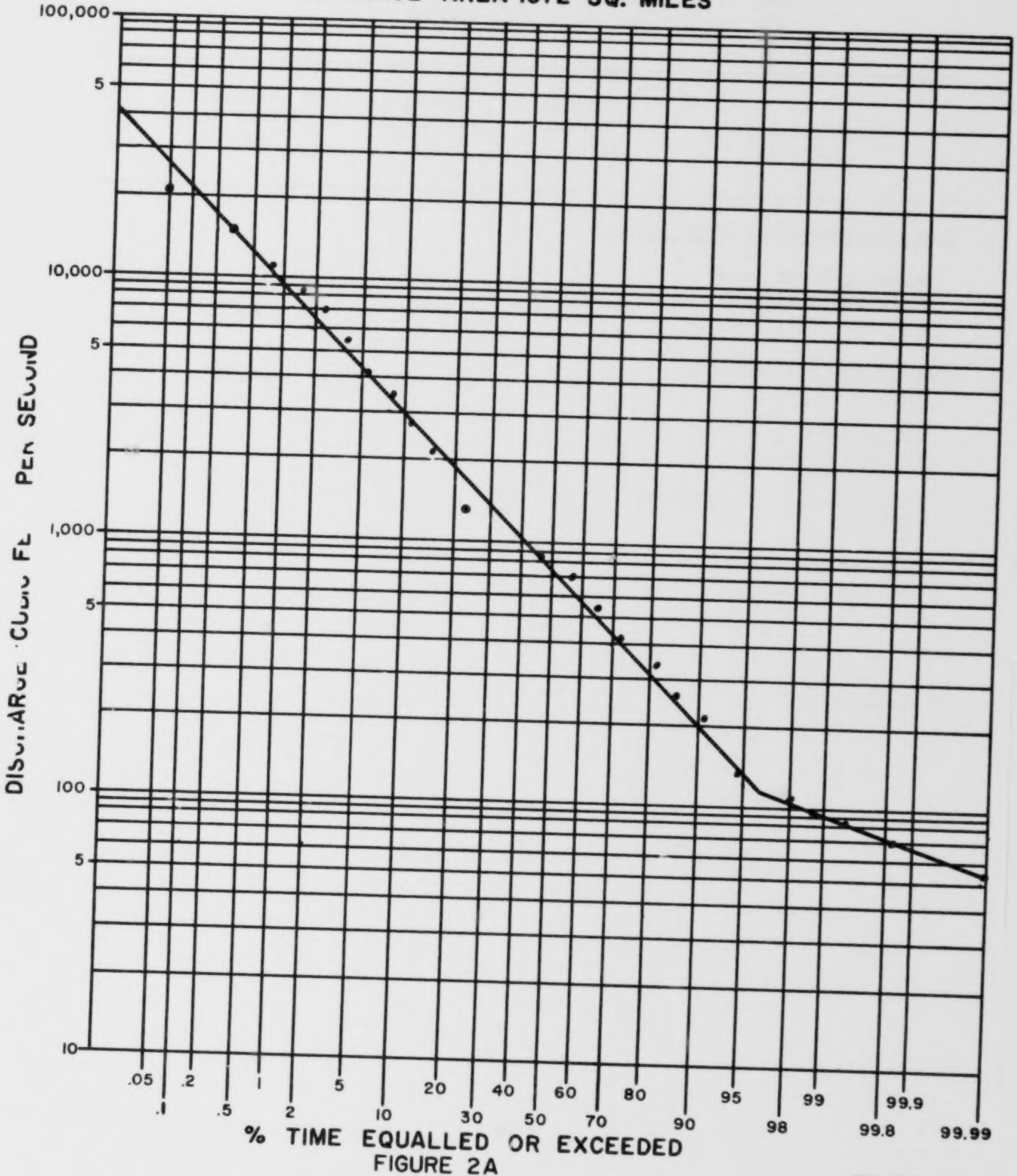

FIGURE 2A

values.

In addition to the natural hydrographic sources a significant quantity of non-saline water is added to the estuary and the Arthur Kill by the discharge of raw and treated municipal and industrial wastes. Such sources average 650 cfs to the Arthur Kill and 105 cfs to Raritan Bay, which is equal to or greater than natural run-off from the Raritan River 30 to 55 percent of the time.

The Project study area is located directly adjacent to the New York metropolitan region, the most heavily populated area of the country. The census figures for 1955 and 1960, as well as projected populations made by the Metropolitan Regional Council for 1965, 1975 and 1985 for the United States as a whole, the New York metropolitan region and the five counties bordering Raritan Bay, are as follows:

	Population in Millions				
	1955	1960	1965	1975	1985
United States	165	179	196	235	286
N.Y. Metropolitan Region	15	16	18	21	24
Five Counties*	1.4	1.6	2.2	3.2	4.3

*Richmond County (Staten Island), N. Y.; Middlesex, Monmouth, Somerset and Union Counties, N.J.

Use of study area waters is not limited to the five directly adjacent counties. Transportation facilities make it possible for a large portion of the New York metropolitan region to take advantage of the facilities of Raritan Bay. In particular, the construction of the Verrazzano-Narrows Bridge, connecting Brooklyn and Staten Island, New York, made it possible for large numbers of people residing in Brooklyn and Long Island to have ready access to the waters of the study area. Since the 1960 Census, which indicated more than 2.6 million inhabitants in Brooklyn, New York, at least an additional 1.0 million persons are now within close proximity of the study area. Should this growth pattern continue through 1985, more than 5.0 million persons, located in the five counties adjacent to the bay plus the western portion of Brooklyn, New York, will be conveniently located in and adjacent to the study area.

PRESENT AND FUTURE WATER USE

Nature and Value of Water Use

Demands of a large population directly adjacent to the study area result in a large variety of uses of

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Raritan Bay and Arthur Kill. These waters are presently, or have been in the past, used for such purposes as: industrial water supply and navigation to meet the demands of the large commercial and industrial development in the area; commercial and shellfishing as a source of food for an expanding market; recreational boating, bathing and fishing to provide adequate leisure for the large and increasing population; and a receiving body for raw and treated municipal sewage and industrial wastes.

Certain of these uses, in particular use as a receiving body for raw and inadequately treated wastes, prevent full development of other water uses as well as being in violation of existing legal standards established for these waters.

Studies were made to determine the magnitude of certain of these water uses. Where possible, present values of particular water uses were estimated. Possible future values associated with certain water uses, which are presently limited or restricted by inadequate water quality, were also forecast. Table IV summarizes the results of these studies. Use of this water resource at the present time amounts to an estimated value of $2.0 million, 90 percent of which is associated with recreation. Development of suitable water quality within Raritan Bay

TABLE IV

ANNUAL VALUES OF THE WATER RESOURCE OF RARITAN BAY

Water Use	Present Value	Potential w/Present Water Quality	Potential w/Suitable Water Quality	Increased Benefits From Improved Water Quality	Remarks
Water Supply					
Municipal	None	-	-	-	(Salinity-No Present Use)
Industrial	N/E	N/E	N/E	N/E	(1,300 MGD Cooling Water)
Commercial Navigation	N/E	N/E	N/E	Ins	(Water Quality has insignificant effect)
Commercial Fishery					
Hard Clam	$ 40,000	$ 250,000[1]	$ 3,850,000	$ 3,600,000	
Soft Clam	Ins	Ins			
Blue Crab	N/E	N/E	N/E[2]	Ins[2]	(Water Quality has insignificant effect)
Fin Fish	200,000	300,000	400,000	100,000	
Sub-Total	240,000	550,000	4,250,000	3,700,000	
Recreation					
Bathing	500,000	500,000	12,000,000	11,500,000	
Boating	760,000	760,000	1,500,000	740,000	
Fish & Waterfowl	468,000	468,000	1,468,000	1,000,000	
Sub-Total	1,728,000	1,728,000	14,968,000	13,240,000	
TOTAL ANNUAL VALUE	$1,968,000	$2,278,000	$19,218,000	$16,940,000	

Notes: N/E = Not Estimated Ins = Insignificant value

1. If suitable transplanting program is developed.
2. The Fish & Wildlife Service estimates that if a suitable market were available this industry could reach a value of $18,000,000 yearly.

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could result in an ultimate value associated with the use of these waters of $19.0 million annually.

Certain water uses listed in Table IV were not assigned dollar values, however, since these uses would not be affected significantly by changes in water quality. Such uses include industrial water supply, commercial navigation, and the commercial blue crab industry.

Water Use Studies

Water Supply

There is no use made of the saline surface waters of the Raritan Bay study area for municipal water supply. Considerable use is made for industrial purposes, generally for cooling and condensing. Available information on industrial use by type of industry is shown in Table V and amounts to 1,300 MGD, 75 percent of which is utilized by the power generating industry.

Because of poor quality many industries provide pretreatment. In particular, the loss of cooling efficiency due to slime accumulations requires chlorination of the raw water. Hence, a reduction in the chlorine demand of the water would be of definite economic benefit, although no attempt was made to determine the magnitude of such benefits.

Commercial Navigation

The New York-New Jersey channel which traverses Raritan Bay is a vital part of the Port of New York, being used by about one-fourth of the ocean-going traffic entering or leaving the port. In 1961, traffic in this channel amounted to nearly 120,000 vessel trips, 4,000 of which were made by vessels with drafts of 20 feet or more. Projections of future growth indicate that by the year 2015, annual traffic in this channel will increase to 200,000 vessel trips, 6,000 by vessels with draft of 20 feet or more.

TABLE V

INDUSTRIAL USES OF STUDY AREA WATERS[1]

Type of Industry	Water Use MGD	Major Use
Petroleum	250	Cooling; Condensing
Chemical	22	Cooling; Condensing
Smelting & Refining	37	Cooling; Condensing
Miscellaneous	2	Cooling
Power Generation	1,000	Cooling
Total	1,311 MGD	

[1] Based upon available data from 1962 Industrial Waste Survey by Interstate Sanitation Commission and New Jersey State Department of Health. Does not include Raritan River.

No dollar value was assigned this use, since it is not significantly affected by water quality.

Commercial Fishery

The commercial fin and shellfish industry was an important use of the water resource of Raritan Bay for many years. However, a combination of overfishing and man-caused environmental changes, such as water pollution, has reduced the value of this use. A study by the Fish and Wildlife Service, United States Department of the Interior, showed that the present shellfish resource in the Project area is limited to hard clams and blue crabs. The hard clam presently provides an annual harvest of only $40,000. The present standing crop, as estimated in a report by the Shellfish Sanitation Branch of the Northeast Research Center, Division of Environmental Engineering and Food Protection, Public Health Service (See Volume III - Appendices) amounts to over $35 million and could provide an annual harvest worth $3.85 million if water quality conditions were suitable. As an alternate, the Fish and Wildlife Service estimates that development of a successful transplanting and purification program could increase the harvest to $250,000 annually with present water quality. The soft clam resource, at one time significant but presently rated as of no significant commerical harvest, is estimated to have a potential commercial value of $18 million annually, assuming suitable water quality and market development. The blue crab commercial fishery appears to be affected only slightly, if at all, by water quality conditions. The 1960 New Jersey blue crab harvest, for example, was the second largest on record.

The Fish and Wildlife Service study estimated the present commercial fin fish harvest in Raritan Bay to have an annual value of $200,000. The industry trend to larger boats and more modern equipment could increase this harvest over a long term to $300,000 annually with present water quality. Improved water quality could raise the fin fish harvest to a potential value of $400,000 annually.

Recreation

The recreational uses of Raritan Bay by the large adjacent population take many forms including bathing, pleasure boating, sport fishing, recreational shellfishing and waterfowl hunting.

A Project study in 1963 of recreational bathing (See Volume III - Appendices) found 59 active bathing beaches on Raritan Bay and Arthur Kill. At several locations bacteriological analyses showed water quality below the recommended safe limits set by the regulatory agencies. The total number of bathers during 1963 was estimated at 1.07 million people. On the basis of the value of $.50 per bather-day recommended by the Federal Joint Task Force on Recreation, the annual value of this resource use in 1963 was $500,000. Beach operators reported an income of $750,000 in 1963, with a total capital investment of $27.8 million at the time of the survey. Estimates of future population growth in the area indicate that with suitable water quality conditions the number of bathers could be increased to at least 16 million per year, with a value of $8 million annually.

In 1963 the Project also conducted a survey of recreational boating in Raritan Bay (See Volume III - Appendices). The survey found a total of 5,480 boats and yachts worth nearly $22 million berthed in or adjacent to the bay. The industry realized a gross income of $2.5 million on a capital investment of $10.5 million. Employment in the industry amounted to 169 man-years in 1963. Using a value of $1.50 per recreation day for boating as suggested by the Ad Hoc Committee on Water Resources, this water use had a value of $760,000 in 1963. The combined effects of increased population, higher income and more leisure and travel time in the surrounding area are expected to produce a rapid growth in recreational boating in Raritan Bay. By 1985, recreational boating will involve more than 1.0 million recreation days, worth an estimated $1.5 million annually.

The Fish and Wildlife Service investigated the value of recreational fin and shellfishing, crabbing and waterfowl hunting in Raritan Bay (See Volume III - Appendices) Based upon values of $1.50 per fisherman-day and $1.00 per man-day for recreational shellfishing, crabbing and waterfowl hunting, these uses of the water resource presently amount to $468,000 annually. The expected future population growth, coupled with improvements in water quality, could increase this benefit to an annual value of almost $1.5 million.

WATER QUALITY CAUSES AND EFFECTS

Water Temperature

Temperature has a direct effect upon the capacity of a receiving water to assimilate oxygen demanding wastes without nuisance. Increases in water temperature reduce the maximum amount of dissolved oxygen which the water can hold. In addition, the exertion of BOD is highly temperature-dependent, with a more rapid demand upon oxygen taking place at higher stream temperatures.

Water temperature also can act as a limiting factor in the survival and propagation of various forms of

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aquatic life. The occurrence of certain biological phenomena such as algal blooms can be directly dependent upon suitable water temperatures.

Water temperatures within the study area are directly affected by the discharge of more than 2 billion gallons of hot cooling water from power generating stations. This thermal pollution is particularly critical in the Arthur Kill, where limited circulation prevents adequate dissipation of the heat. A comparison of influent and effluent water characteristics from power generating stations has indicated the effluent to be as much as 15°F warmer than the incoming water. Analytical results reported for water temperature in the Arthur Kill indicate a warming of this waterway. It should be noted, however, that the sampling stations utilized were in the center of the channel; and, therefore, higher water temperatures would be expected in the immediate vicinity of the discharge of heated wastes.

Dissolved Oxygen Relationships

Adequate levels of dissolved oxygen in water are necessary to provide an environment suitable for survival and propagation of fish and other forms of aquatic life. A lack of dissolved oxygen in industrial water supplies prevents the formation of the metallic oxides which reduce or prevent corrosion of process piping. Further, dissolved oxygen is necessary to stabilize organic and chemical wastes. When adequate levels of dissolved oxygen are not available in a receiving water to satisfy the imposed BOD and COD loadings, septic conditions result.

The amount of dissolved oxygen in a water depends on the rate of natural aeration or transfer from the atmosphere, photosynthesis, imposed oxygen demanding load, water salinity and temperature. In the areas covered by the Project water salinity and temperature are extremely important. With a chloride concentration of 15,000 mg/l and a water temperature of 26°C, only 7.0 mg/l of dissolved oxygen could be held by a water at 100 percent saturation. Such conditions of salinity and temperature have been observed in the study area, especially in the Arthur Kill. In order to provide at least 4.0 mg/l for a healthy fish habitat under such conditions a dissolved oxygen level of at least 57 percent saturation is required. The large oxygen demanding loads resulting from the discharge of raw and treated industrial and municipal wastes into the study area waters prevents dissolved oxygen levels from reaching this point. An additional oxygen demanding load is brought into the study area by pollution sources as far distant as

Newark Bay and Upper Bay.

Arthur Kill analytical results indicate that this waterway contained 270,000 pounds BOD and 1.0 million pounds COD resulting from pollutional discharges. Project studies revealed that 250,000 lbs/day of BOD were discharged to the kill by municipalities and industries. Industrial waste discharges contributed 190,000 lbs/day of COD. Thirty percent of the BOD and 85 percent of the COD loadings came from two industries -- Humble Oil and Refining Co. and General Aniline and Film Corp.

Raritan Bay receives 185,000 lbs/day of BOD, only 1.0 percent of which was attributable to industry. Nearly 90 percent of the total BOD load was found to be from one source -- Middlesex County Sewerage Authority.

Waste loadings to the Raritan River were estimated at 75,000 lbs/day of BOD, 98 percent of which is from industrial sources.

Dredging operations, while a necessary factor in the maintenance of navigational channels throughout the study area, and an important source of construction material for the metropolitan New York complex, impose an undetermined oxygen demanding load on these waters as a result of resuspension of organic matter from the bottom materials.

High pollution loadings result in critical dissolved oxygen levels in certain portions of the study area. In some portions of the Arthur Kill the oxygen demand exceeds the total available capacity of the water, resulting in conditions of zero dissolved oxygen over large stretches of the kill. This low dissolved oxygen in the kill is an important factor in the inability of the Arthur Kill to sustain a normal aquatic population.

Pollutional loads entering from the Raritan River and Arthur Kill lower the dissolved oxygen levels in the western portion of Raritan Bay, particularly during the summer and autumn period. Low dissolved oxygen levels are found in the northeastern area of Raritan Bay as a result of organic loads entering the bay through the Narrows. An important factor in the maintenance of dissolved oxygen levels in the bay is the photosynthetic production by a number of types of algae. The net yield to the waters serves to maintain satisfactory oxygen levels in much of the bay.

In certain reaches of the Raritan River the imposed loadings result in a severe depletion of dissolved oxygen. During the summer of 1964 septic conditions were noted immediately upstream of the Fieldville Dam. The formation of floating mats and production of hydrogen sulfide gas rendered the stream unsuitable for recreation or other uses.

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Nutrients

When other environmental factors such as temperature, sunlight and salinity are satisfactory, both nitrogen and phosphorus become critical nutrients for the growth of algae. These algae are desirable in limited quantities as a necessary link in the food chain which supports aquatic life. However, should eutrophication, or fertilization of the water with excess nutrients, occur, algal growths may exceed desirable limits, and in some cases create nuisance blooms. Such blooms are unsightly, can result in obnoxious odors, and may result in a lowering of dissolved oxygen levels to below those needed for other forms of aquatic life.

Nitrogen and phosphorus are found in the discharge of municipal and industrial wastes regardless of the stage of normal treatment provided. The low nitrogen to phosphorus ratio reflects the influence of sewage discharged to these waters. In the Arthur Kill, and on occasion in Raritan Bay, the nitrogen to phosphorus ratio was less than 1. Such ratios indicate advanced eutrophication of the receiving water, which results in an abundance of plankton in both the Arthur Kill and Raritan Bay at certain seasons of the year. The profusion of the major algal types found in the bay are related to specific nutrients supplied by municipal and industrial waste discharges.

The low dissolved oxygen values found during late spring and early summer in Raritan Bay are the result of a combination of two plankton populations which develop because of the advanced eutrophication of these waters. The decline of the winter-spring algal bloom reduces photosynthetic production of oxygen. Simultaneously, the planktonic population of active respirator animals reaches its peak. Hence, the low dissolved oxygen concentrations found during this period can be attributed, at least in part, to eutrophication of these waters which makes possible such changes in the plankton population.

Phenolic-Type Compounds

Phenolic-type compounds in water can result in tainting of fish flesh and shellfish meats, thus restricting legitimate use of the water for recreational fin and shellfishing. In addition, phenol can serve to inhibit the growth of aquatic organisms, as it is a widely used disinfectant.

Phenol pollution of a water may result from the discharge of municipal and industrial wastes; however, it is commonly associated with petroleum wastes. High concentrations

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of phenol were found in those portions of the study area adjacent to petroleum manufacturers, in particular, toward the northern end of the Arthur Kill. Phenol content in the kill was estimated as 6,000 pounds. A survey of industry indicated that nearly 11,000 lbs/day of phenol is discharged to the kill, 98 percent of which emanates from three industries -- Humble Oil & Refining Co., E. I. duPont de Nemours-Grasselli, and General Aniline and Film Corp. The transport of phenols through the Arthur Kill and also through Upper Bay via the Narrows results in high penol concentrations at the eastern and western extremities of Raritan Bay.

Analyses of shellfish meats taken from Raritan Bay indicated higher phenol concentrations in these meats than are found in shellfish taken from unpolluted waters. Uptake of phenols in growing waters taints the meat so as to render this food unsuitable for market. During Project studies it was found that the majority of both recreational and commercial fishing is done outside the limits of the study area because the uptake of phenolic-type compounds and similar materials produced undesirable tastes in fish taken from Raritan Bay.

Oil and Grease

Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full esthetic enjoyment of the water. Such slicks may also interfere with the normal transfer of oxygen from the atmosphere into the water. Deposition of oil in the bottom sediments can serve to inhibit normal benthic growths, thus interrupting the aquatic food chain. Certain oils can produce a tainting of shellfish meats, thus rendering them unsuitable for use as food.

Oil and grease observed in Raritan Bay and the Arthur Kill are the result of the discharge of treated and untreated industrial and municipal wastes, spillage from dockside fueling and petroleum transfer activities, bilge pumping and spillage and engine exhaust from recreational boating.

In certain areas of the Arthur Kill the bottom sediment was heavily contaminated with oil and devoid of normal aquatic life. Shellfish meats taken from Raritan Bay showed contamination by mineral oils to levels greater than that encountered in shellfish from unpolluted waters.

Industrial wastes surveys revealed that more than 19,000 lbs/day of oil is discharged to the Arthur Kill. More than 90 percent of this is attributable to discharges from two plants -- Humble Oil & Refining Co. and General Aniline and Film Corp.

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Bacteria Densities

Total coliform densities, as determined by the MPN test procedure, have traditionally served as an indicator of pollution. Most established standards relating to water use, both for internal consumption and for recreational exposure and contact, are based upon this indicator organism. The New York City Department of Health, for example, has established a maximum allowable total coliform MPN limit of 2,400 per 100 ml for recreational bathing.

While total coliforms are used as indicators of pollution, it is recognized that these organisms may originate from non-human sources. Hence, other indicator organisms such as the fecal coliform group are used to further identify possible human contamination. The presence of such organisms above certain acceptable levels is indicative of the presence of human wastes which may contain pathogenic organisms capable of causing disease in humans.

High bacterial densities were found in areas of the bay influenced by discharges from the Arthur Kill, Raritan River and Upper Bay. High bacterial loadings at the junction of the Arthur Kill and Raritan River resulted in the closing of a public bathing beach in the City of Perth Amboy, New Jersey. Bacteria counts in excess of the maximum limits for bathing established by the New York City Department of Health were found at all but two sampling stations on the Staten Island shoreline from the Narrows to Tottenville. These high counts, combined with the results of dye studies which indicate that unchlorinated human wastes from Upper Bay reach Staten Island bathing beaches within six hours, indicate a definite health hazard to persons utilizing the waters of the Staten Island shoreline for recreational purposes.

In 1961 an epidemic of infectious hepatitis was traced to raw shellfish taken from Raritan Bay. Project analyses of these shellfish showed high densities of pollution indicator bacteria in the meats, thereby indicating contamination from human sewage and confirming the hazard associated with the ingestion of raw shellfish meats. The majority of shellfish showing high bacteria counts were taken from those growing areas within the influence of the discharge of unchlorinated wastes entering the study area through the Narrows.

Although high coliform counts indicate a potential health hazard to users of a water, such bacteria are not normally pathogenic. Isolation of pathogenic bacteria, such as Salmonella, is positive proof that a health hazard exists.

Salmonella were isolated from raw sewage discharged into Upper Bay immediately above the Narrows and also in the waters of the Narrows. Salmonella of the same serotype were found in the waters of the easterly area of Raritan Bay and on the bathing beaches of Staten Island. The area of isolation coincides with the area shown by dye studies to be directly affected by Upper Bay.

Salmonella of the same serotype found in the Narrows and in the bay water south of the Narrows were also found in shellfish meats taken from the eastern area of Raritan Bay. The presence of such organisms, which are capable of causing serious illness when present in a source of human food, further confirms the health hazard associated with the discharge of unchlorinated human excrement into Raritan Bay waters.

POLLUTION ABATEMENT PROGRAM

Enforcement Activities

Since the first session of the Conference on Pollution of Raritan Bay and Adjacent Waters, the State of New Jersey, City of New York and the Interstate Sanitation Commission have issued enforcement orders in an attempt to control pollution of the study waters. The following is a brief description of these orders and the latest known status of enforcement.

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New Jersey State Department of Health

The New Jersey State Department of Health has issued abatement orders against a number of municipalities and industries as a result of previously existing regulations and of classification proceedings of the study area waters. The latest information available on the status of these orders is as follows:

1. Hatco Chemical Company, Division of W. R. Grace Co. - On December 21, 1962, orders were issued requiring pollution abatement by April 15, 1963. Early in 1966 the company became a participant in the Middlesex County Sewerage Authority. In April of that year the company began to make payments to the Authority for treatment services, although the actual interceptor connection was delayed until November 1966 due to right-of-way negotiations. This facility is still discharging contaminated cooling waters to the Raritan River.

2. Union Carbide, Plastics Division - A pollution abatement order was issued July 14, 1942, against the predecessor corporation, Bakelite. The Union Carbide Corporation is reported to have a continuing program of investigation and isolation of sources of pollution from the stormwater and cooling water systems, and to have initiated a feasibility

study for diversion of stormwater for treatment by filtration, chlorination, and chemical treatment. By early 1967 the majority of plant wastes, exclusive of contaminated cooling waters, was treated by the Middlesex County Sewerage Authority.

3. Stabilized Pigments, Inc. - A pollution abatement order of December 21, 1962, required this company to complete its program by April 15, 1963. In April 1966 the company was placed under a court order restricting plant operations due to air pollution problems. Further enforcement of water pollution abatement orders has been held in abeyance pending a satisfactory conclusion of the air pollution problem.

4. General Aniline & Film Corporation - Pollution abatement orders were issued January 22, 1963, requiring control of pollution discharges by January 27, 1964. The company has met with the Health Department on a number of occasions to discuss its program. As of early 1967, this program has not been completed.

5. American Cyanamid Company (Linden) - Pollution abatement orders were issued January 22, 1963, calling for completion of a control program by January 27, 1964. In June 1964 the company advised the Health Department that the necessary equipment had been installed. The company program is to include barging of certain wastes to sea for ocean disposal.

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The necessary barge is under construction and scheduled to be placed in operation by July 1, 1967.

6. Reichhold Chemical Company (Elizabeth) - Pollution abatement orders were issued January 23, 1963, requiring completion of abatement activities by January 7, 1965. In June 1964 the firm advised the Health Department of plans to connect to municipal sewers owned by Elizabeth Joint Meeting. Connection to these sewers was completed in January 1966.

7. Humble Oil & Refining Company - Pollution control orders were issued January 22, 1963, requiring abatement by January 27, 1964. In April 1964 the firm indicated it had scheduled necessary activities for all work to be completed by the end of 1965. The sour water treatment facility, completed in late 1966, provides treatment to the largest BOD source in the plant. The west side chemical products separator has been completed. Spent caustic is now being loaded on barges and shipped for sale. As of early 1967, additional work to reduce pollution from this source was under way.

8. Philip Carey Manufacturing Co. - Pollution abatement orders were issued September 1, 1961, requiring the adoption of a program by December 1, 1961. The Health Department turned this case over to the Office of the State Attorney General for prosecution. In November 1966, a court

order was issued requiring abatement by April 1967.

9. Hess Oil & Chemical Company - Pollution abatement orders were served on August 26, 1964, and required completion of abatement activities by December 15, 1964. In December 1964 the firm submitted a progress report indicating partial abatement had been achieved. In early 1966 the company requested a conference with the Health Department to discuss its progress in pollution abatement. By early 1967, the company was reported to be working on plans for accomplishing abatement.

10. Borough of Highlands - Pollution abatement orders issued December 11, 1964, required the construction of necessary improved treatment facilities by April 1, 1965. In 1965 the Borough initiated studies to determine the feasibility of joining with Sea Bright and Rumson in a regional project, as well as the feasibility of connecting with the proposed Monmouth County Sewerage Authority. No decision has been made as to which regional approach will be selected.

11. Linden-Roselle Sewage District - Orders against this agency were issued January 22, 1963, requiring increased treatment by January 27, 1964. In January 1965 the Authority advised the Health Department that it was operating a pilot plant prior to construction of the

necessary facilities for secondary treatment. By early 1967, pilot plant studies had been completed and an abatement timetable submitted.

12. Woodbridge Township (Sewaren) - Orders were issued on January 22, 1963, requiring increased treatment at this plant by January 27, 1964. An engineering study was completed on methods for providing increased treatment. The township has also completed a study to determine the feasibility of connecting to the Middlesex County Sewerage Authority system as an alternate to upgrading existing treatment facilities.

13. Rahway Valley Sewerage Authority - Orders were issed January 22, 1963, requiring increased treatment by January 27, 1964. In September 1964 this agency advised the Health Department it was conducting pilot plant studies prior to the design of new treatment facilities. These studies are now under way, and an abatement timetable has been submitted.

14. Carteret - A consent judgment which will incorporate a time schedule for completion of activities, is being issued against the Borough of Carteret by the court. The Borough has undertaken a study to determine possible improvements in the collection system to reduce waste flow and the feasibility of joining the Rahway Valley Sewerage

Authority as an alternate to upgrading existing facilities.

15. Joint Meeting - Engineering studies to achieve abatement were completed in late 1966.

Classification of the Raritan River and Raritan Bay in February 1966 has resulted in issuance of orders requiring submission of plans for secondary treatment for a number of communities and industries. The following list presents the polluters, the dates of orders, and the compliance date for submission of plans for upgrading to secondary treatment.

	Date Issued	Compliance Date
American Cyanamid Company (Bound Brook)	2-18-1966	6-1-1966
Johns Manville Products Corporation	2-18-1966	6-1-1966
Middlesex County Sewerage Authority	2-18-1966	6-1-1966
Borough of Manville	2-18-1966	6-1-1966
City of Perth Amboy	2-18-1966	6-1-1966
Borough of Sayreville	2-18-1966	6-1-1966
City of South Amboy	2-18-1966	6-1-1966
Woodbridge Township	2-18-1966	6-1-1966
Madison Township Sewerage Authority	4-7-1966	8-15-1966
Borough of Keyport	4-7-1966	8-15-1966
Borough of Keansburg	4-7-1966	8-15-1966
Borough of Atlantic Highlands	4-7-1966	8-15-1966
Borough of Matawan	4-7-1966	8-15-1966
Matawan Twp. Mun. Ut. Auth. (2 plants)	4-7-1966	8-15-1966

According to the Health Department, as of early 1967 virtually all of the above were making satisfactory progress, either in developing plans for upgrading existing facilities or in conducting studies to determine the feasibility of regional facilities.

New York City Department of Health

This agency has issued a number of orders against pollution. In many cases actual construction of pollution control facilities is being held in abeyance pending construction of municipal facilities by the City of New York. In early 1967 the status of orders issued by this agency was as follows:

1. Mount Loretto Home - Abatement orders issued March 27, 1962, were complied within April 1964.
2. St. Joseph's By-The-Sea - Abatement orders were issued March 27, 1962, against a system which is no longer in use. The sewage disposal facility of the new high school has been approved by the City Department of Health.
3. Richmond Memorial Hospital - Abatement orders were issued March 15, 1962. Compliance was obtained in

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September 1964, but due to poor operation the facility is presently not satisfactory.

4. Nassau Smelting - Abatement orders were issued on March 27, 1962. An extension has been granted until May 1969, the expected completion date of the Tottenville treatment plant. The necessary internal piping changes must be made prior to May 1969 so that immediate connection to the city sewer will be possible at that time.

5. Procter & Gamble - On April 5, 1963, this firm was ordered to abate pollution by April 1964. An extension has been granted until the Port Richmond West Branch interceptor is completed in June 1968. The necessary internal piping changes must be made prior to June 1968 to permit immediate connection to the city sewer at that time. Design work to accomplish this connection has been substantially complete.

6. S. S. White Company - Abatement orders were issued March 15, 1962. An extension has been granted until completion of the Oakwood Beach interceptor in April 1969. The necessary internal piping changes must be made prior to April 1969 to permit immediate connection to the city sewer at that time.

Interstate Sanitation Commission

This agency has one abatement order outstanding against the City of Elizabeth, requiring construction of interceptor sewers for two areas now discharging raw sewage to the Arthur Kill. Plans and specifications have been completed, and bids for this work are due April 11, 1967.

Plans and Construction of Municipal Plants

Through the combined efforts of State and interstate agencies responsible for pollution control in the area, a number of municipalities have undertaken necessary construction plans and studies to upgrade treatment levels, as follows:

1. Keyport - In 1962 this municipality completed a modernization and expansion program for its primary treatment plant at a cost of $361,000. It is now studying a regional approach rather than upgrade this plant to secondary.
2. Keansburg - In 1963 this municipality initiated a program of expansion for both its treatment plant and sewer system. Treatment plant additions were completed in 1964 to increase the plant design flow to 2.5 MGD at a

cost of $190,000. The estimated cost for the completion of the sanitary sewer system was $160,000. The community is now investigating a regional facility in lieu of increased treatment.

3. Madison Township (Laurence Harbor) - In 1963 a new primary plant with a design flow of 1.0 MGD was placed in operation. Treated waste is discharged through an outfall 1,700 feet into Raritan Bay. Design of secondary treatment facilities is under way.
4. Atlantic Highlands - In 1964 the municipality completed preliminary plans for a new secondary treatment plant. It then abandoned these plans and made a study of the feasibility of connecting to the proposed Monmouth County Sewerage Authority system. No decision has been made as to which approach will be taken.
5. Port Richmond - In 1964 New York City expended $973,900 for construction of a slude storage tank and plant modifications. Plans for the West Branch interceptor have been completed and construction is scheduled for completion by June 1968. Eventually this plant will intercept and treat all wastes being discharged from Staten Island between the Narrows and Port Ivory. In addition, a completed study of the Bloomfield area indicated that this area should also be served by the

Port Richmond plant. The East Branch interceptor is scheduled to be completed by December 1969. By December 1969, the plant will be expanded to provide secondary treatment to 60 MGD with discharge to the Kill Van Kull. Estimated cost for this program is $40,981,000.

6. Tottenville - In 1964 the State of New York approved $103,000 for a comprehensive study for sewerage facilities for this area. By late 1966 this study had been completed. Present plans call for construction by May 1969 of a 6 mgd secondary plant with the necessary interceptor sewers, at an estimated cost of $4,631,000.
7. Newton Creek - Construction of the Newton Creek plant was completed in late 1966 at a cost of $48,800,000. Initial operation is scheduled for early 1967. This plant, which will provide secondary treatment for 310 MGD, will be a major step in reducing pollution in Upper Bay. Interceptor sewers to serve the eastern portion of Manhattan Island are scheduled for completion by September 1968. The total cost for this plant and necessary interceptor sewers is estimated at $165,240,000.
8. Middlesex County Sewerage Authority - In 1965 the Authority installed two new clari-flocculators which

increased plant capacity from 52 to 78 MGD. The cost of this and other plant expansion programs was $1,093,100. The Authority has completed pilot plant studies and initiated design of secondary treatment facilities.

9. Fresh Kills, Staten Island - In 1965, the State of New York approved a study for this plant, now approximately 50 percent complete. This project will intercept and treat all wastes being discharged to the Arthur Kill from Staten Island from Fresh Kills south to the Outerbridge Crossing. Construction of a 10 MGD secondary plant and the necessary interceptor sewers is estimated to cost $11,677,000. Expected completion date is May 1971.
10. Oakwood Beach - Final design has been completed for the South Shore interceptor, now scheduled for completion of construction by April 1969. Following this and completion of plant expansion to 30 MGD, now scheduled for December 1970, all wastes from Staten Island between the Narrows and Princes Bay will receive secondary treatment prior to discharge. Estimated cost for this work is $29,578,000.
11. Red Hook - Preliminary plans were completed in 1965 for the East Branch interceptor. Selection of plant site and type of treatment are under way. This project will provide a secondary plant to treat 60 mgd of wastes now

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being discharged immediately north of the Narrows along the Brooklyn shore. Total cost of this project is estimated at $44,309,000. Expected completion date for the plant and interceptor sewers is December 1970.

12. Highlands - In 1965, the borough abandoned its plans for a secondary treatment plant in order to investigate connection to the proposed Monmouth County Sewerage Authority. It has now abandoned this approach in favor of a connection to the Borough of Seabright.
13. Monmouth County - A study of the feasibility of a Monmouth County Sewerage Authority to serve the entire area of Monmouth County, New Jersey, has been completed and submitted to the New Jersey Health Department for review.

State and Interstate Programs

Prior to convening of the conference on pollution of Raritan Bay, the waters of the conference area had been classified by the Interstate Sanitation Commission and by the New York State Water Resources Commission. Their classifications are presented in the section of this report entitled "Pollution Abatement Needs."

In 1962 the Interstate Sanitation Commission issued a report on treatment requirements in the Arthur Kill. This report was based upon a study of the assimilative capacity of the Arthur Kill and established the following requirement for domestic and industrial waste discharges to these waters:

> "Domestic and Industrial waste plants must provide at least 75% reduction in the total pounds of BOD discharged per day or full secondary treatment with an 80% reduction in BOD, whichever produces the lower effluent BOD, as well as comply with all other standards."

In August 1964 the New Jersey State Department of Health issued regulations establishing a classification procedure for water within its jurisdiction. Effective April 15, 1965, classifications and criteria were adopted for the Raritan River and Raritan Bay below Fieldville Dam. In January 1966 the Department issued its proposed classifications for the Arthur Kill and its tributaries. Both of these classifications are presented in the section of this report entitled "Pollution Abatement Needs."

A number of important activities were also accomplished during 1965. New York State declared that all discharges to waters within Interstate Sanitation Commission jurisdiction emanating from the State of New York must provide secondary treatment. The State of New Jersey also agreed to require secondary treatment on all discharges throughout the Interstate Sanitation Commission district. The Interstate Sanitation Commission issued a requirement for chlorination of all wastes discharged to the Upper Bay by the summer of 1967. According to the Interstate Sanitation Commission most of the sources discharging to the Arthur Kill have agreed to meet the Commission's requirement for secondary treatment, and it is expected that such treatment will be provided by sources no later than the end of 1968.

In September 1965, new legislation was passed in the State of New York providing increased enforcement capability and authority to the New York State Health Department. In November 1965, voters in New York State approved a one billion dollar bond issue to make possible more rapid construction of needed waste treatment facilities throughout the State.

The impact of the discharge of raw or inadequately treated and disinfected wastes from the Upper Bay upon the waters of the study area has been discussed previously. In September of 1965, the Secretary of Health, Education, and Welfare called a conference on pollution of the Hudson River and its tributaries. The conferees included the New York and New Jersey State Health Departments, the Interstate

Sanitation Commission, and the Department of Health, Education, and Welfare. Among the recommendations adopted by the Conferees and promulgated by the Secretary of Health, Education, and Welfare following the conference were the following:

> "All discharge sources to the Hudson River and its tributaries, whether public, Federal installations, or industrial, shall receive a minimum of secondary treatment or its equivalent, and effective disinfection of the effluents as required to protect water uses.
>
> "Industrial plants shall improve practices for the segregation and treatment of wastes to effect the maximum reduction of the following:
>
> a. Acids and alkalis;
> b. Oil and tarry substances;
> c. Phenolic compounds and organic compounds that contribute to taste and odor problems;
> d. Nutrient materials including ammonia, nitrogenous and phosphoric compounds;
> e. Suspended material;
> f. Toxic and highly colored wastes;
> g. Oxygen requiring substances;
> h. Heat;

i. Foam producing discharges;

j. Other wastes which detract from recreation uses, esthetic enjoyment or other beneficial uses of the waters.

"Surveillance and monitoring of the operation and maintenance of sewage and waste treatment facilities in the conference area shall be conducted by the States of New Jersey, New York, the Interstate Sanitation Commission, and the Department of Health, Education, and Welfare at locations and frequencies to yield reliable values of waste outputs and resulting receiving water quality, and to show their variations.

"The Federal conferee recommends the following time schedule for the foregoing program:

a. Designs for remedial facilities completed by January 1, 1967;

b. Financing arrangements completed by April 1, 1967;

c. Construction started by July 1, 1967;

d. Construction completed and plants placed into operation by January 1, 1970;

e. Commensurate schedules should be adopted for the interception and treatment of industrial wastes and wastes from Federal installations;

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f. Existing schedules calling for earlier completion dates are to be met.

"The magnitude of the pollution problem caused by discharge from combined sewer overflows is recognized. The Department of Health, Education, and Welfare, in cooperation with the States of New Jersey, New York, and the Interstate Sanitation Commission, will undertake a review of the problem and develop a program for action for consideration by the Federal Government, the States and the Interstate Sanitation Commission by December 31, 1968."

Completion of the activities called for in the above recommendations will be of benefit to the waters of Raritan Bay by reducing the waste load entering the system through the Narrows.

POLLUTION ABATEMENT NEEDS

Classification and Water Quality Standards

Waters of the study area have been classified as to best usage by the agencies having authority to promulgate such classifications -- New York State Water Resources Commission, New Jersey State Department of Health, and Interstate Sanitation Commission. Each of these agencies, in adopting classifications for the various segments of water within the study area, have also promulgated applicable water quality standards based upon the assigned water usages. Table VI presents the existing classifications by these agencies, together with the highest assigned usage under classification. The study waters embrace a total of eight different classifications.

There is a need for a better definition of the assigned usages. The Interstate Sanitation Commission, operating under the provisions of the Tri-State Compact, has established two classifications. Class A is assigned to those waters expected to be used primarily for recreational purposes, shellfish culture, or the development of fish life. Class B waters are defined as those not expected to be used primarily for the same purposes. Such broad classification makes difficult the assignment of appropriate standards. Case in point: Bacterial standards for all Class A waters should be set for the highest permissible use -- shellfish propagation. In certain areas, however, optimum water use may be fish propagation or recreational use, both of which may require less stringent bacterial standards.

Water quality criteria promulgated by each agency for their classification assigned to these waters are contained in Volume III -- Appendices.

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Most of the criteria shown in Table VI are in general terms, with numerical values assigned only to a few parameters such as dissolved oxygen, pH and bacteria levels. Table VII compares the dissolved oxygen and bacterial criteria promulgated by each agency for various types of usage. There is a need for the regulatory agencies to agree on uniform criteria for identical classes of water quality. Although New York and New Jersey have identical bacterial standards for shellfish waters, the Interstate Sanitation Commission standard is based upon effluent quality rather than the quality of the shellfish water itself. New York and New Jersey standards do not indicate a bacterial criteria for bathing waters; however, the Interstate Sanitation Commission has a standard based upon effluent quality control.

Both New Jersey and the Interstate Sanitation Commission have similar dissolved oxygen requirements for shellfish and bathing waters -- not less than 50 percent of saturation; New York, however, calls for not less than 5 mg/l. With a chloride value of 12,500 mg/l and a water temperature of 25°C, both conditions of normal occurrence in the water under study, 50 percent dissolved oxygen saturation corresponds to a concentration of only 3.7 mg/l, a figure significantly less than the 5 mg/l required by New York. In their criteria for non-recreational waters both New York

TABLE VI

EXISTING CLASSIFICATIONS OF STUDY WATERS

	Agency & Classification			Highest Assigned Usage under Classification
Water Area	New York Water Resources Commission	New Jersey State Dept. of Health	Interstate Sanitation Commission	
Arthur Kill - Outerbridge Crossing to Newark Bay	II	TW-3	B	Non-Recreation & Navigation
Arthur Kill - Outerbridge Crossing to Tottenville	I	TW-3	A	Shellfish (ISC) Recreation (ISC) Fishing (N.Y.)
Raritan Bay	SB	TW-1	A	Shellfish (ISC & NJ) Bathing (NY & NJ)
Raritan Bay Shellfish Area	SA	TW-1	A	Shellfish (ISC,NY,NJ)
Lower Bay	SB	-	A	Shellfish (ISC) Bathing (NY)
Sandy Hook Bay	-	TW-1	A	Shellfish & Bathing (NJ, ISC)
Raritan River, from Fieldville Dam to Raritan Bay	-	TW-1	-	Shellfish & Bathing (NJ)

TABLE VII

COMPARISON OF WATER QUALITY CRITERIA

		Criteria for	
Agency & Class		Dissolved Oxygen	Coliform Bacteria
		Shell Fishing for Market Purposes	
NY	SA	NLT* 5.0 mg/l	Median MPN not over 70/100 ml
NJ	TW-1	NLT 50% of Saturation	Median MPN not over 70/100 ml
ISC	A	NLT 50% " "	Effluent NGT** 1/ml in more than 50%
		Bathing	
NY	SB	NLT 5.0 mg/l	No criteria
NJ	TW-1	NLT 50% Saturation	No criteria
ISC	A	NLT 50% Saturation	Effluent
		Fishing	
NY	I	Ave. NLT 50% any week NLT 3.0 mg/l anytime	Effluent disinfection if required by ISC
NJ	-		
ISC	-		
		Non-Recreational Use	
NY	II	Ave. of NLT 30% saturation any wk. of year	-
NJ	TW-3	NLT 30% saturation or 3 mg/l whichever is less	-
ISC	B	NLT 30% saturation	-

*NLT = Not less than
**NGT = No greater than

and the Interstate Sanitation Commission require not less than 30 percent dissolved oxygen saturation. New Jersey, on the other hand, has a dissolved oxygen requirement of not less than 30 percent saturation or 3 mg/l, whichever is less. Again, under the same conditions of temperature and chloride noted previously 30 percent saturation of dissolved oxygen could present levels as low as 2.2 mg/l in the water.

In addition to the need for uniform classifications and water quality criteria, there is a need for more specific definitions of such terms as medium, average and sampling frequency.

Proposed Water Quality Requirements

Tables VIII through X present recommended water quality requirements to be applied to the Arthur Kill, Raritan Bay, and Raritan River. These requirements are recommended as indicating water quality suitable for the highest assigned usage by the three agencies which have classified these waters.

Requirements for the Arthur Kill are such as to permit utilization of this water for pleasure boating, commercial navigation and survival of aquatic life. In addition, criteria were selected so as to minimize the effect of the Arthur Kill upon the adjoining waters of Raritan Bay.

Requirements for Raritan Bay and Raritan River include two bacteriological limits, applicable to either shellfish areas or to water contact recreational areas. Since the majority of water contact recreation is in the form of bathing along the shoreline, higher limits have been set to allow for a reasonable amount of soil runoff from the shore. The commercial shellfishing areas, on the other hand, are removed from such runoff influences and the more stringent bacterial requirements can be maintained if pollution is controlled.

TABLE VIII

WATER QUALITY REQUIREMENTS

ARTHUR KILL

Location - Arthur Kill from Outerbridge Crossing north to Port Ivory.

Water Use - Pleasure boating, commercial navigation, industrial cooling water, wastewater assimilation.

Coliform Bacteria - Number/100 ml

Maximum value 5,000 except during periods of stormwater runoff.

Paul DeFalco

TABLE VIII

(Continued)

Fecal Coliform - Number/100 ml

Maximum value 500 except during periods of stormwater runoff.

Turbidity

No turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of the water.

Odor

No obnoxious odors of other than that of natural origin.

Temperature °F

No single daily value more than 90°.

Oil

Substantially free from visible floating oil.

Floating Solids and Debris

Substantially free of floating solids and debris from other than natural sources.

Bottom Deposits

Substantially free of sludge banks and oil deposits.

Dissolved Oxygen - mg/l

Average (May through September) not less than 4.0. No single daily value less than 2.5.

TABLE VIII

(Continued)

Phenolic-Type Compounds - mg/l

No single daily value more than 0.02.

Toxic Substances

None in such concentrations as to render the water unsuitable for the assigned uses.

TABLE IX

WATER QUALITY REQUIREMENTS

RARITAN BAY AND RARITAN RIVER

Location - All areas of Raritan, Lower and Sandy Hook Bays not used for commercial shellfish propagation; Raritan River from Raritan Bay to Fieldville Dam; tidal portions of tributaries to these waters unless classified separately.

Water Use - Recreational bathing and boating, propagation of commercial and sport finfish.

TABLE IX

(Continued)

Bacteria - Number/100 ml

(a) Number of bacteria shall be the arithmetic average of the last five consecutive sample results.

(b) Satisfactory area if coliform are less than 1,000 and Fecal Coliform less than 200.

(c) Single sample results of over 5,000 coliforms shall require immediate investigation as to cause. Items to be considered in the judgment of cause and action to be taken include the sanitary survey, winds, currents and weather conditions.

(d) The above notwithstanding, isolation of any known pathogenic bacteria shall render the area unsatisfactory.

Turbidity

No turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of water.

Odor

No obnoxious odor of other than natural origin.

TABLE IX

(Continued)

Temperature - °F

Not more than 85°.

Oil

Substantially free of visible floating oil.

Floating Solids and Debris

Substantially free of floating solids and debris from other than natural sources.

Bottom Deposits

Substantially free of muck and debris of other than natural origin.

Dissolved Oxygen - mg/l

Annual Average: Not less than 5.0

Single Value: Not less than 4.0

Phenolic-Type Compounds - mg/l

Not more than 0.005

Miscellaneous Trace Contaminants and Radionuclides

Shall not be present in such concentrations as to render the water unsuitable for the assigned uses.

Paul DeFalco

TABLE X

WATER QUALITY REQUIREMENTS

RARITAN BAY SHELLFISH AREAS

Location - Those areas of Raritan, Lower and Sandy Hook Bays used for commercial shellfishing.

Water Use - Commercial shellfish.

Coliform Bacteria - Number/100 ml

Mean MPN value not greater than 70 and no more than ten percent in excess of 230. All provisions for sanitary quality as described in the "National Shellfish Sanitation Program Manual of Operations," U. S. Dept. of Health, Education, and Welfare, shall apply.

Other Parameters

Criteria for all parameters other than bacteria shall be as indicated in Table IX, Requirements for Raritan Bay and Raritan River.

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Treatment and Surveillance

In certain cases, the present waste loads imposed upon the study area waters exceed the available assimilative capacity. Improved treatment -- secondary being a required minimum -- is needed to reduce the quantity of oxygen demanding wastes now being discharged by both industries and municipalities. Control of the present bacteriological contamination at bathing beaches and shellfish waters requires a program of year-round effective disinfection of all sewage now being discharged to the study waters and to adjacent waters as far north as those around Manhattan Island in Upper Bay.

The present sewered population discharging directly to the study waters is estimated at 1.25 million persons. With the contemplated growth rate of the area, the sewered population is expected to increase ultimately to 3.6 million. This increase in tributary population accentuates the need for a minimum of secondary treatment of all wastes. When the sewered population approaches the ultimate secondary treatment may not be sufficient; therefore, advanced waste treatment processes may be required to protect these waters. Such advanced processes, commonly referred to as tertiary treatment, have yet to be applied on such a large-scale basis; however, development of these techniques is proceeding in such a fashion that adequate treatment methods will be available when needed. It is important to note that the effectiveness of increased treatment measures will be reduced if municipalities and industries do not provide qualified operators and sufficient funds for maintenance and operation.

Agencies having jurisdiction should reallocate their priorities for State and Federal construction grants and similar assistance to those areas affecting water quality in Raritan Bay in order to insure prompt construction of needed new plants and the upgrading of existing facilities. Particular emphasis should be placed on support of the necessary public expenditures for upgrading treatment. Once construction has been completed those agencies having jurisdiction should undertake more rapid enforcement of existing rules and regulations relating to water pollution control, including programs aimed at insuring compliance by adequate surveillance and inspection activities.

Due to contamination in localized areas such as marinas and docks, regulations should be adopted requiring adequate treatment facilities on all recreational and commercial vessels utilizing these waters. In the event holding tanks are utilized by such vessels adequate shore facilities must be required to handle wastes from these sources and proper regulations developed to insure use of such facilities.

Until such time as the above actions have been taken and decreases noted in the present bacterial contamination, the responsible authorities should undertake such measures as are necessary to reduce hazards to the health of persons utilizing these waters. The existing restrictions on harvesting of shellfish for commercial purposes should be continued until such time as improvement in water quality has been sufficient to warrant their reopening. The use of the waters by the public for water contact recreation, such as bathing, should be similarly restricted to those areas free of contamination.

Proposals such as the barrier at the mouth of the Narrows should be evaluated by water pollution control agencies, not as an alternate to, but as an additional measure for protection for these waters.

Additional removal of industrial waste contaminants will be required to permit restoration of the waters of the Arthur Kill to levels suitable for propagation of aquatic life and for non-contact water-based recreation. The specific assignment of permissible waste loadings should be made by the responsible agencies having jurisdiction, utilizing as guidelines studies conducted by the Interstate Sanitation Commission of available assimilative capacity in the Arthur Kill and the criteria presented previously in Table VIII.

Such assignment of permissible waste loadings should consider increases in loads anticipated as a result of future growth of both municipal and industrial developments utilizing the Kill as a receiving stream.

At this point, I would like Kenneth Walker to present some of the analytical results, and I will return to complete the report.

MR. STEIN: Thank you, Mr. DeFalco.

Mr. Walker?

STATEMENT OF KENNETH H. WALKER, DEPUTY DIRECTOR, RARITAN BAY PROJECT, FEDERAL WATER POLLUTION CONTROL ADMINISTRATION, DEPARTMENT OF THE INTERIOR, METUCHEN, NEW JERSEY

MR. WALKER: My name is Kenneth Walker. I am Deputy Director of the Project. I am starting on Page 49 of Volume I, the analytical results.

ANALYTICAL RESULTS

General

The following results of chemical, bacteriological and biological studies in the waters of the Project study area are based upon a variety of sampling programs. In Raritan Bay and Arthur Kill the Project conducted an intensive sampling operation, with weekly sampling at each station during the 13-month period from August 1962 through September 1963. From September 1963 to May 1966 the Project conducted a surveillance program which involved collecting of monthly samples at selected stations in the Bay and Kill.

The intensive sampling program was designed to permit mathematical analyses of the variations noted in parameter values. The results of such analyses are presented in detail in the section of this report entitled "Special Studies." The surveillance operation was pursued so as to maintain updated water quality data and to provide information on any changes which might have occurred during the period of surveillance. The sampling stations used by the Project in Raritan Bay and Arthur Kill are presented in Figure 3.

Analytical data presented on the Raritan River are based upon samples collected by the Project as well as data supplied by the Middlesex County Sewerage Authority. The sampling stations utilized on the Raritan River are shown in Figure 4.

Discussion of results has been divided into the three major bodies of water studied -- Raritan Bay, Arthur

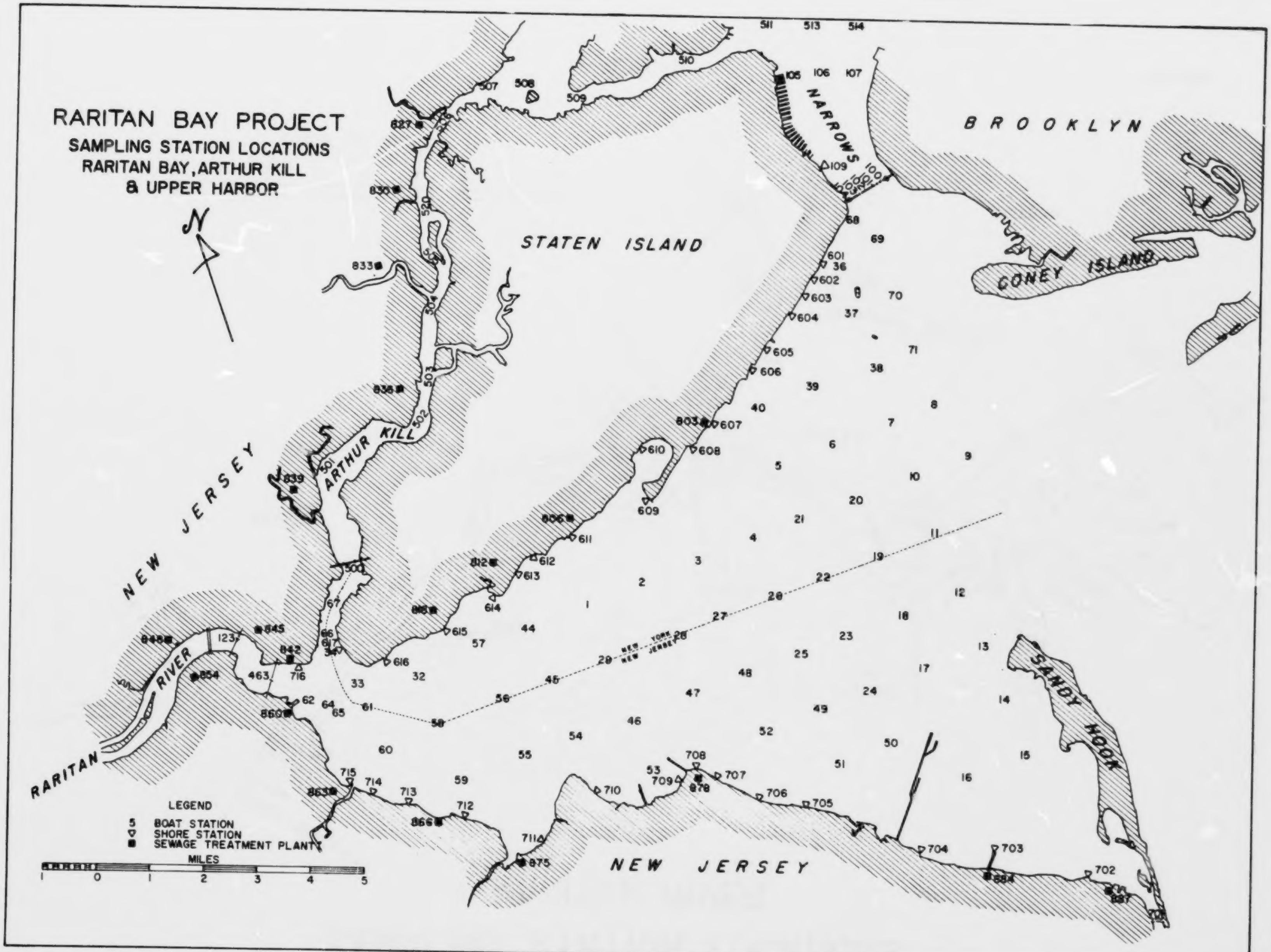
RARITAN BAY PROJECT
SAMPLING STATION LOCATIONS
RARITAN BAY, ARTHUR KILL
& UPPER HARBOR
N
STATEN ISLAND
BROOKLYN
CONEY ISLAND
NARROWS
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW JERSEY
NEW YORK
NEW JERSEY
LEGEND
5 BOAT STATION
▽ SHORE STATION
■ SEWAGE TREATMENT PLANT
MILES
1
0
1
2
3
4
5
511
513
514
510
507
508
509
106
106
107
109
100
101
102
103
827
830
833
836
839
520
504
503
502
501
500
68
69
601
36
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
803
806
812
818
842
845
848
854
860
863
866
875
878
884
887
70
37
71
38
39
40
8
7
6
5
9
10
20
21
4
3
2
1
11
19
22
26
27
28
29
12
18
23
25
44
57
32
33
45
56
58
61
62
64
65
66
67
463
123
716
60
55
54
46
47
48
49
24
17
13
14
15
16
50
51
52
53
59
708
709
707
706
705
704
703
702
710
711
712
713
714
715

FIGURE 3

GPO 956-592

SAMPLING STATION LOCATIONS
RARITAN RIVER

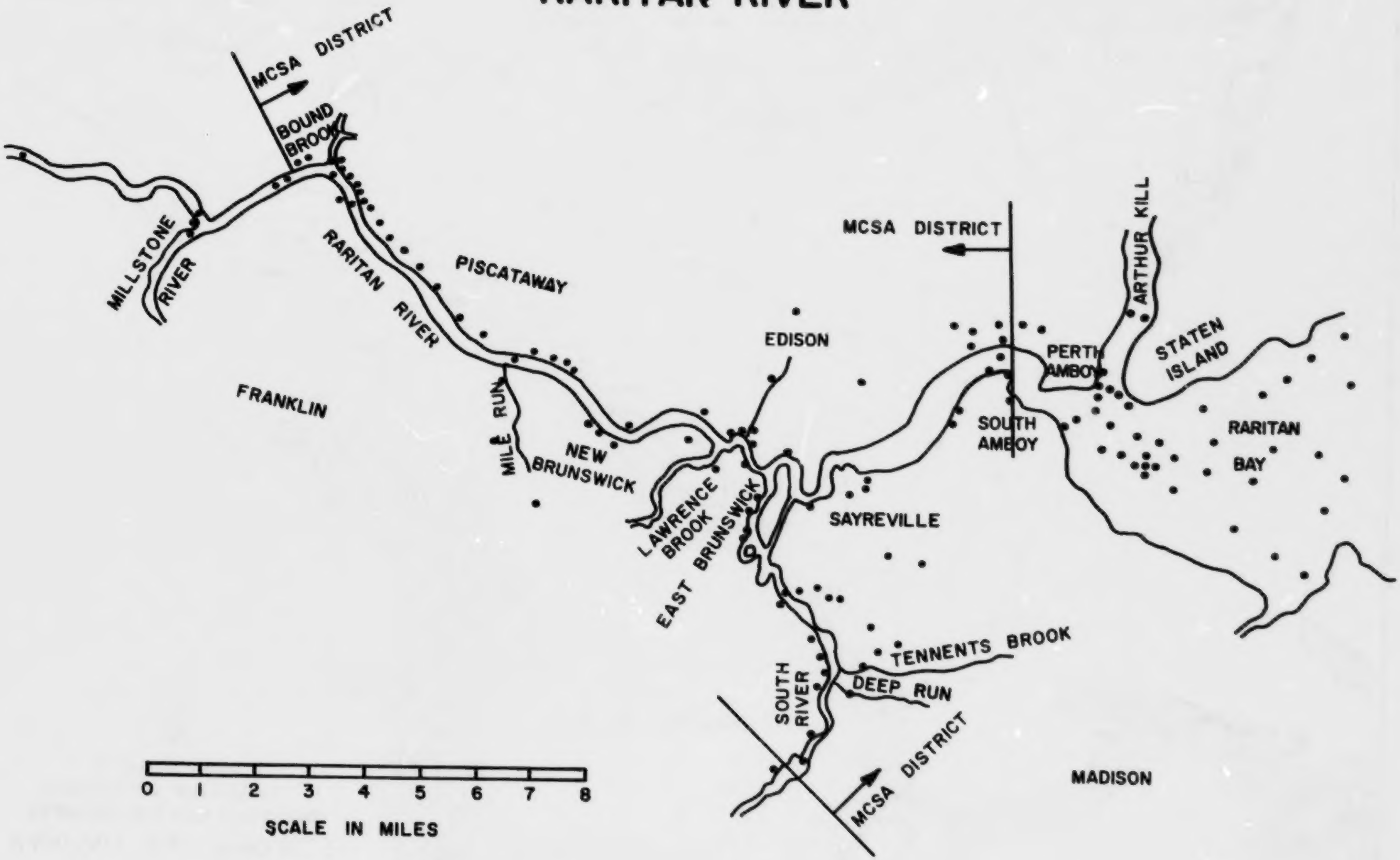
MCSA DISTRICT
BOUND BROOK
MILLSTONE RIVER
RARITAN RIVER
PISCATAWAY
FRANKLIN
MILE RUN
NEW BRUNSWICK
LAWRENCE BROOK
EAST BRUNSWICK
EDISON
SAYREVILLE
MCSA DISTRICT
SOUTH AMBOY
PERTH AMBOY
ARTHUR KILL
STATEN ISLAND
RARITAN BAY
TENNENTS BROOK
DEEP RUN
SOUTH RIVER
MCSA DISTRICT
MADISON
0 1 2 3 4 5 6 7 8
SCALE IN MILES

FIGURE 4

Kill, and Raritan River. Where statistically significant, the predominant cycles affecting parameter variations, as determined by the mathematical analyses, have been included.

Raritan Bay

Water Temperature

Mean water temperatures were found to be uniform throughout the bay, averaging from 15 to 16°C. For 44 stations mathematical analyses indicated an expected range of water temperature from -1.3 to 26.1°C, and with a mean value of 12.4°C. The major variation in water temperature was found to be due to an annual seasonal cycle.

Chloride

Mean chloride concentrations were uniform throughout, averaging from 13,000 to 14,000 mg/l. The predominant component affecting chloride concentrations, which could be explained by mathematical analyses, was an annual variation.

BOD_5

Mean observed BOD values ranged from an average of 3 to 4 mg/l in the western end of the bay to values of less than 2 mg/l at the ocean extremity. The highest BOD value observed was 11 mg/l at Station 56. During the surveillance operation, a maximum of 12.0 mg/l was found at Station 27.

Dissolved Oxygen

Average dissolved oxygen concentrations, as shown in Figure 5, ranged from 6 mg/l at the mouth of the Arthur Kill to values of 9 mg/l in the center of the bay along a band reaching from Princess Bay, Staten Island, to Sandy Hook Bay. East and north of this band average dissolved oxygen levels decreased to 6 mg/l. The highest average dissolved oxygen level -- 10 mg/l -- was found in Sandy Hook Bay. Minimum dissolved oxygen values recorded were approximately 2 mg/l at all stations except 34, where levels as low as 1.4 mg/l were observed.

Variation in dissolved oxygen throughout the bay was attributed to a predominant annual variation with

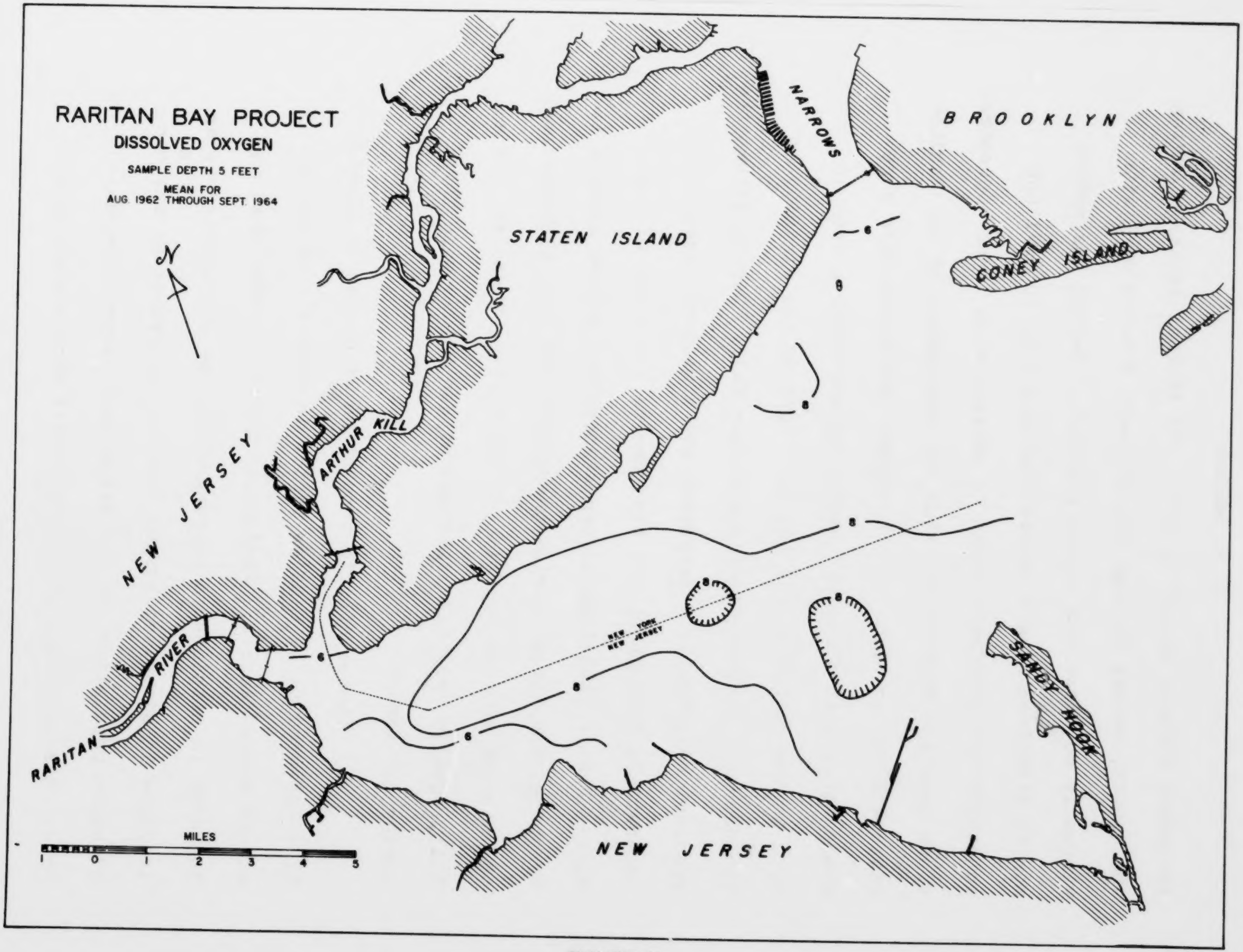
RARITAN BAY PROJECT
DISSOLVED OXYGEN
SAMPLE DEPTH 5 FEET
MEAN FOR
AUG. 1962 THROUGH SEPT. 1964
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
6
8
8
8
8
8
8
6
6
MILES
1 0 1 2 3 4 5

FIGURE 5

secondary effects caused by tidal and diurnal cycles. During the winter, values through the bay were 9 to 10 mg/l with virtually no dissolved oxygen gradient. During the spring months dissolved oxygen values remained 9 to 10 mg/l but concentration gradients began to appear, with lower concentrations near the Narrows and near the confluence of the Raritan River and Arthur Kill. In the summer gradients were more pronounced, with dissolved oxygen values ranging from 10 mg/l in the center of the bay to 4 mg/l in the vicinity of the Narrows, Raritan River and Arthur Kill. During autumn the gradient essentially disappeared and dissolved oxygen concentrations throughout the bay were on the order of 5 to 7 mg/l. From a dissolved oxygen standpoint, autumn appears to be the most critical period throughout the bay, although near the Narrows and the junction of the Raritan River and Arthur Kill, equally critical dissolved oxygen values were found during the summer.

Photosynthetic production of oxygen by aquatic life appeared to be a major factor in maintaining bay dissolved oxygen levels. Biological surveys showed that an increase in netplankton concentration was accompanied by an increase in dissolved oxygen levels. Increases in the zooplankton population, on the other hand, were accompanied by decreasing dissolved oxygen levels with a simultaneous occurrence of lowest dissolved oxygen concentrations and peak zooplankton populations. Respiration of the dominant zooplankters found during peak populations could utilize as much as 27 mg/l per day of oxygen, according to previous studies.* This large loss of oxygen due to respiration was offset, at least partially, by simultaneous blooms of nanoplankton, which are active oxygen producers.

Special studies were conducted at two stations in Raritan Bay to determine the net effect of photosynthetic production and respiration by marine organisms. The results, presented in Figure 6, suggest that oxygen production in the bay is essentially limited to the top 11 feet, with peak production occurring in the upper six feet. Between 38 and 55 percent of the oxygen produced by photosynthesis was consumed by respiration, with the remainder being made available to the waters of the bay.

Dissolved oxygen mean concentrations found during surveillance studies were about 1 mg/l lower in the western end of the bay than those observed during the intensive study. Other areas of the estuary remained unchanged.

Phenol

Limited analyses for phenolic-type compounds

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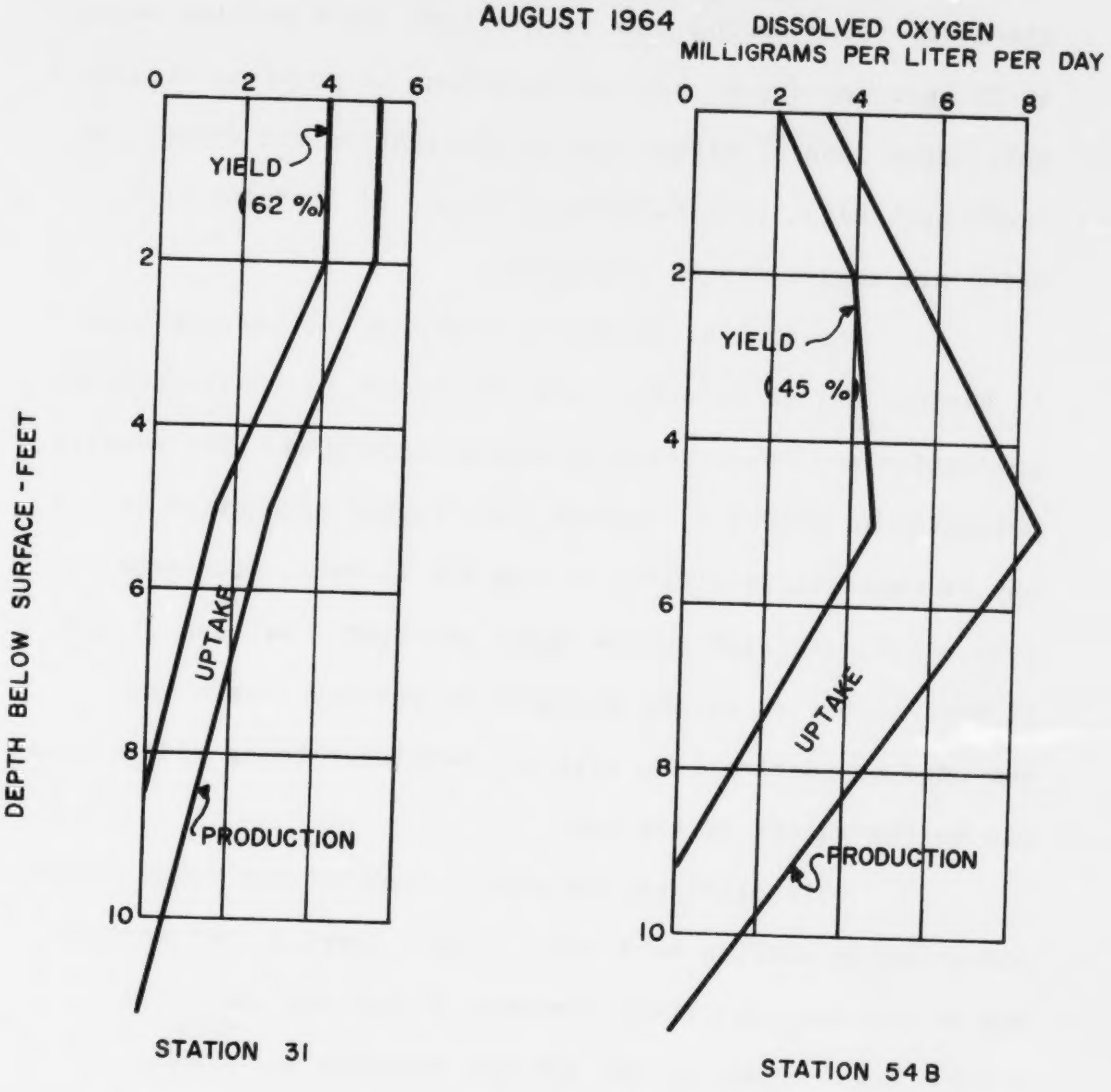
* Conover 1959

OXYGEN PRODUCTION, UPTAKE & YIELD

PHOTOSYNTHETIC ZONE

RARITAN BAY

AUGUST 1964



STATION 31

STATION 54 B

FIGURE 6

indicated maximum values of phenol of 8 to 12 ppb at both the easterly and westerly extremities of the bay. At the easterly end phenol values were highest near the Narrows and decreased uniformly on a line towards Sandy Hook Bay.

Bacteriological Density

Analyses were performed for total coliform and fecal coliform by both MPN and MF procedures and for fecal streptococcus by MF procedures. Figure 7 presents the mean MPN confirmed coliform counts for the bay. Again, these are mean values. High densities were found both in the vicinity of the Narrows and at the junction of the Arthur Kill and Raritan River. From these two sources coliforms appeared to radiate out into the bay. Those stations with the lowest mean counts form an apparent edge between the two radiating sources appearing as a straight band running from lower Staten Island, to Sandy Hook Bay. Geometric mean counts for MPN confirmed coliform ranged from 10,000 per 100 ml at the Narrows, and 7,000 per 100 ml at the mouth of the Raritan River to less than 50 per 100 ml in Sandy Hook Bay.

Figure 8 presents the bacteriological counts found along a profile following the New York-New Jersey State line through the bay. For each of the indicator

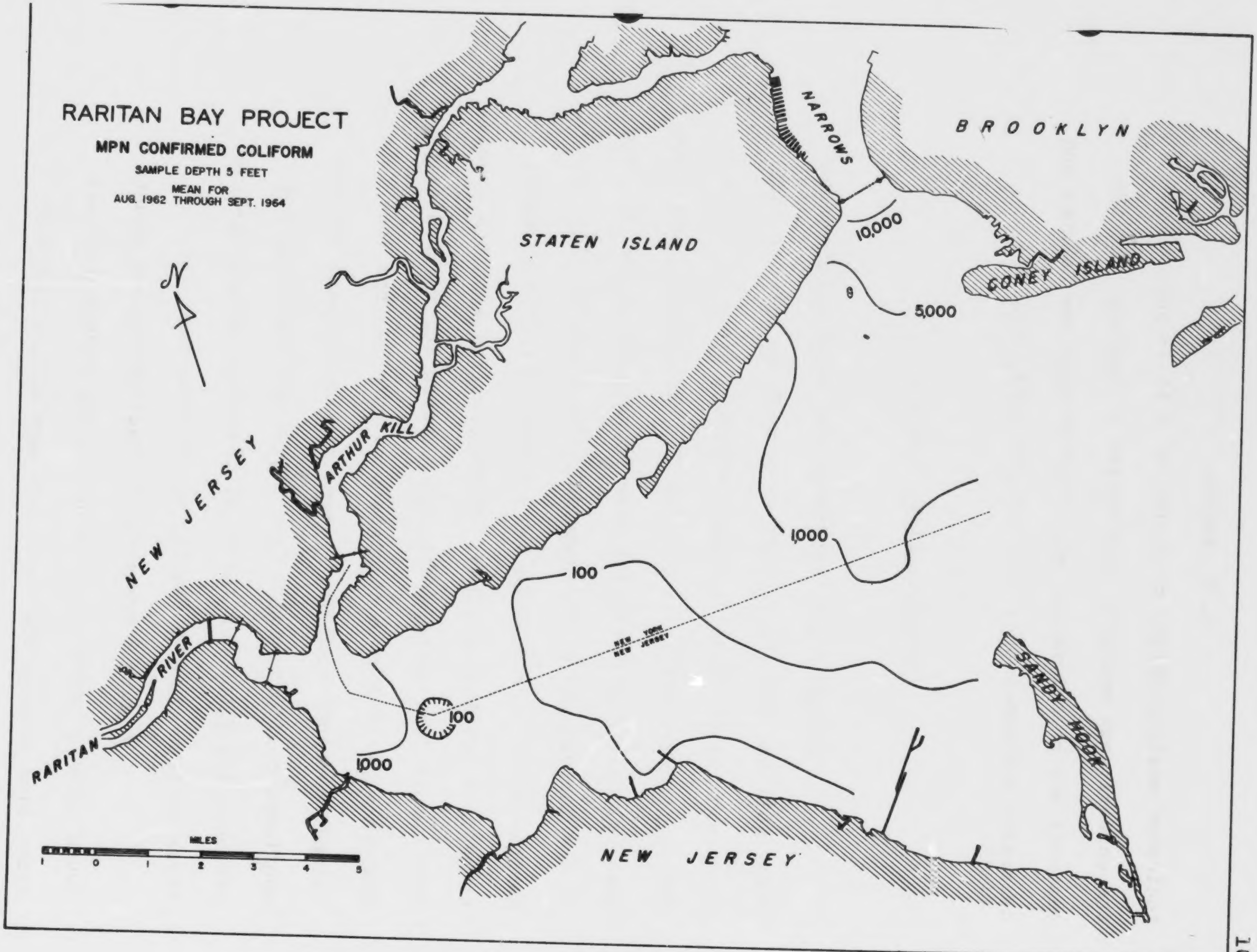

RARITAN BAY PROJECT
MPN CONFIRMED COLIFORM
SAMPLE DEPTH 5 FEET
MEAN FOR
AUG. 1962 THROUGH SEPT. 1964
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
10,000
5,000
1,000
100
NEW YORK
NEW JERSEY
100
1,000
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW JERSEY
MILES
1
0
1
2
3
4
5

FIGURE 7

RARITAN BAY PROJECT
BACTERIAL PROFILES
N. Y.-N. J. STATE LINE

SAMPLE DEPTH 5 FEET

MEAN FOR
AUG. 1962 THROUGH SEPT. 1964

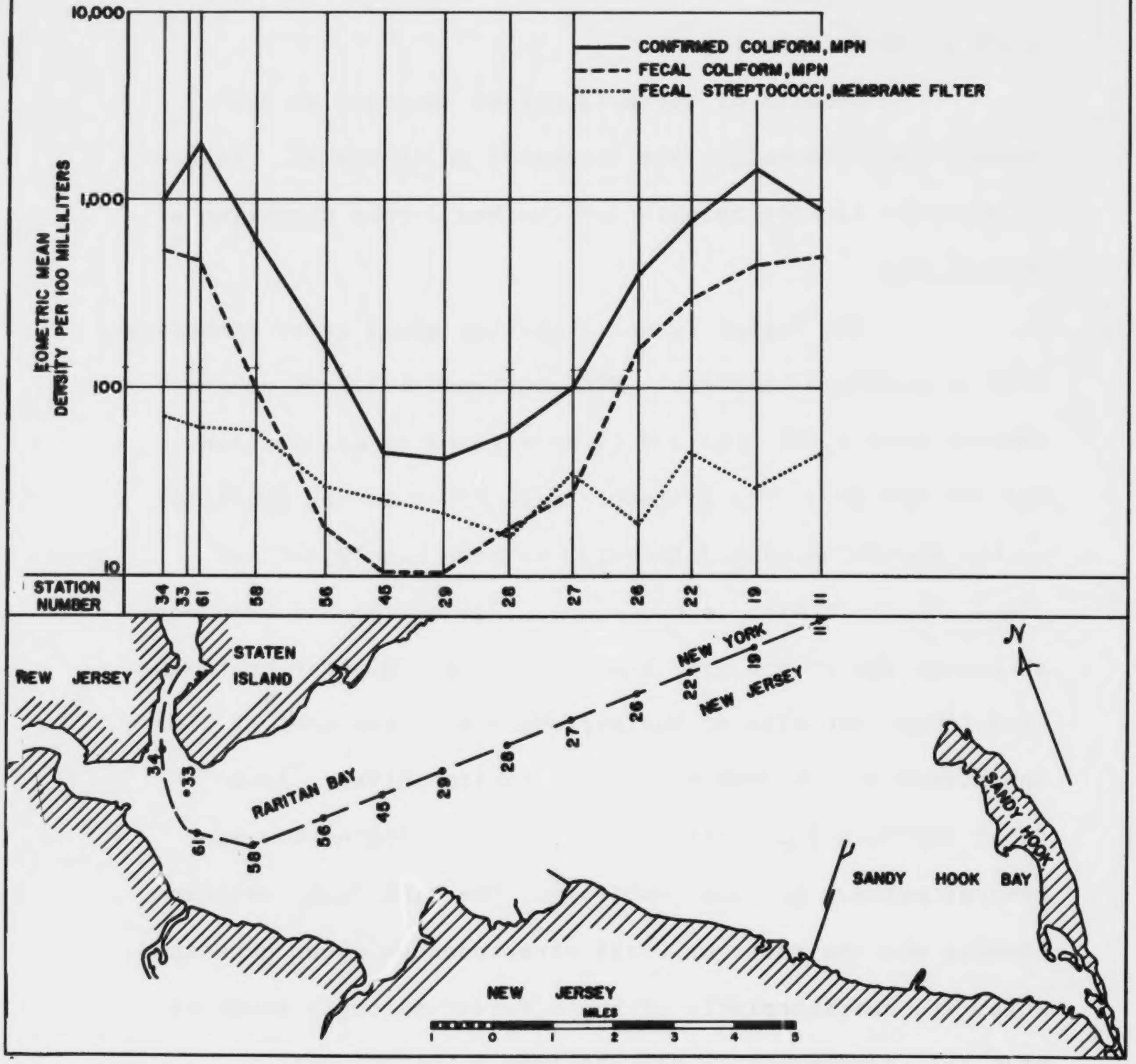


FIGURE 8

organisms, high counts were observed at both extremities of the profile with a reduction of counts near the center. A similar profile extending from the Narrows to Sandy Hook, as shown in Figure 9, indicates a high bacteriological density in the vicinity of the Narrows with a decline proceeding south to Sandy Hook Bay.

Results of bacteriological sampling on the Staten Island shoreline are presented in Figure 10. Figure 11 presents similar results for the New Jersey shoreline of Raritan Bay.

The Staten Island shoreline shows gross contamination by coliform bacteria. MPN confirmed coliform counts greater than 2,400 per 100 ml were found at all stations but 607 and 609. The geometric mean MPN coliform densities on the shoreline ranged from 100 to more than 2,400 per 100 ml on the Staten Island shore. Highest counts were noted at either end of the profile, indicating a greater contamination in the vicinity of the Narrows and in the area of the confluence of the Arthur Kill and Raritan River. Both fecal coliform and fecal streptococcus exhibited the same general pattern as total coliform. The high fecal coliform density and the ratio of fecal streptococcus group organisms, which are characteristic of human feces, strongly suggests that this contamination results from human sources.

RARITAN BAY PROJECT
BACTERIAL PROFILES
EASTERN EXTREME OF BAY

SAMPLE DEPTH 5 FEET

MEAN FOR
AUG. 1962 THROUGH SEPT. 1964

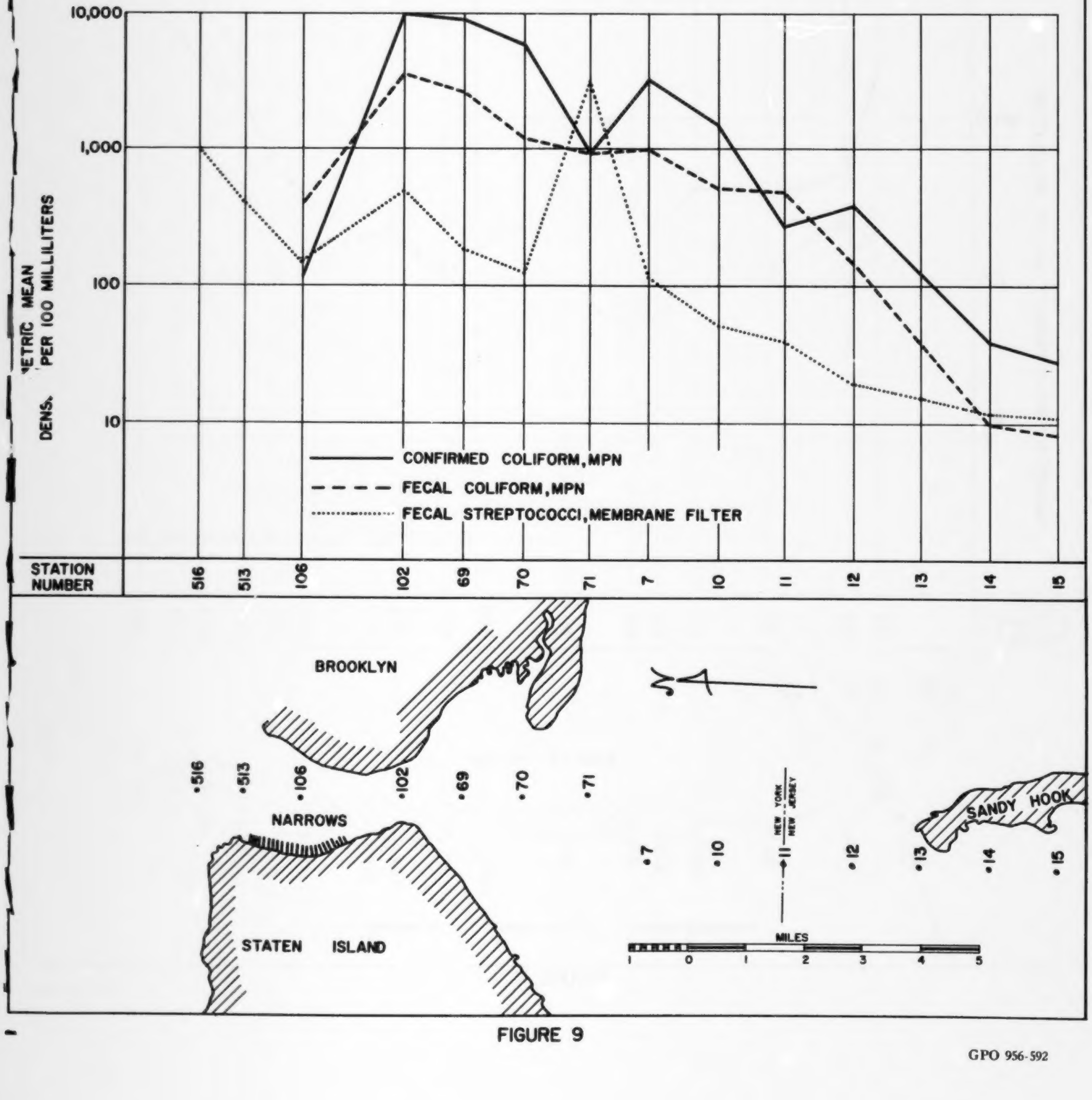


FIGURE 9

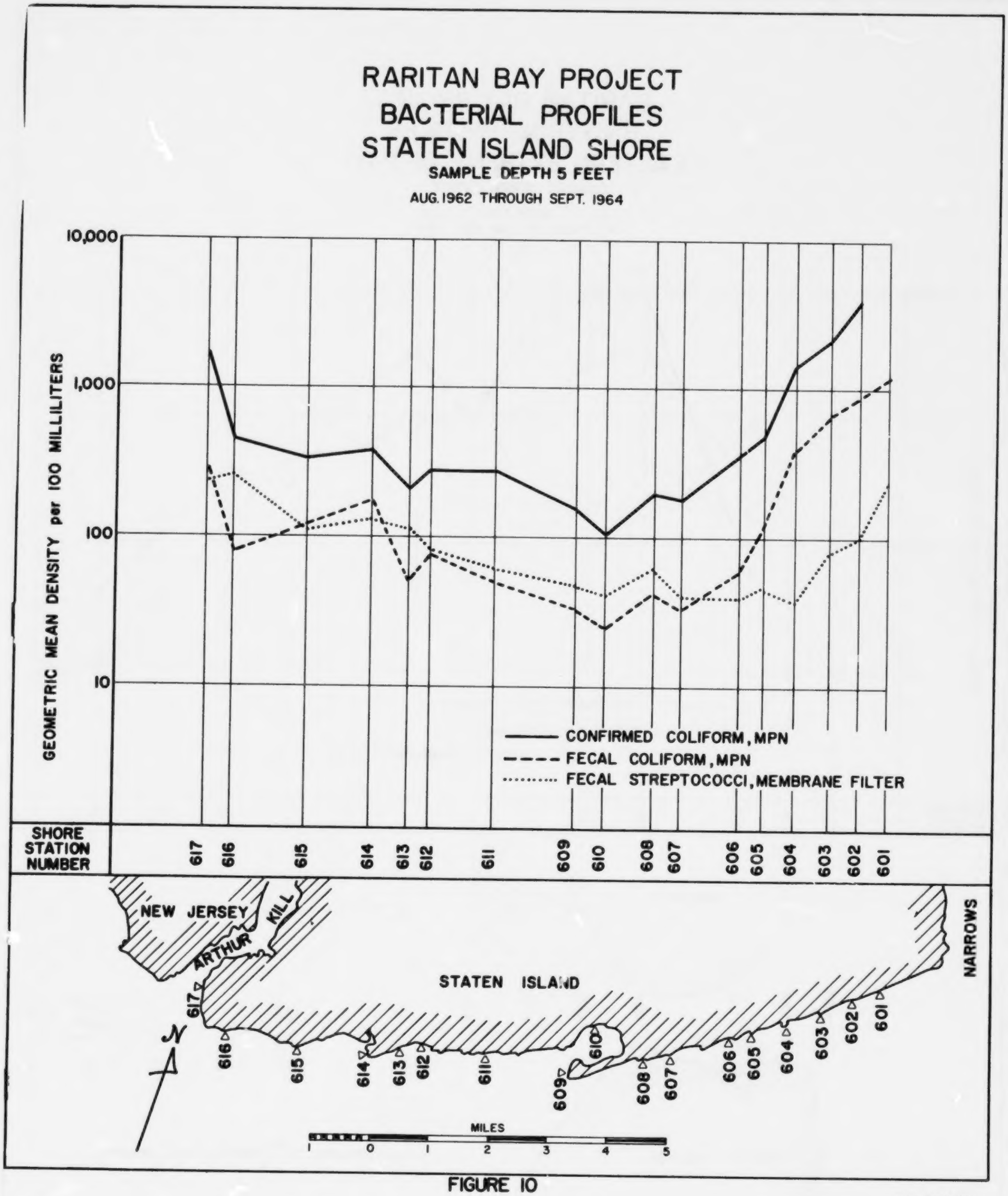

RARITAN BAY PROJECT
BACTERIAL PROFILES
STATEN ISLAND SHORE
SAMPLE DEPTH 5 FEET
AUG. 1962 THROUGH SEPT. 1964
GEOMETRIC MEAN DENSITY per 100 MILLILITERS
10,000
1,000
100
10
CONFIRMED COLIFORM, MPN
FECAL COLIFORM, MPN
FECAL STREPTOCOCCI, MEMBRANE FILTER
SHORE STATION NUMBER
617
616
615
614
613
612
611
609
610
608
607
606
605
604
603
602
601
NEW JERSEY
ARTHUR KILL
STATEN ISLAND
NARROWS
N
MILES
1
0
1
2
3
4
5

FIGURE 10

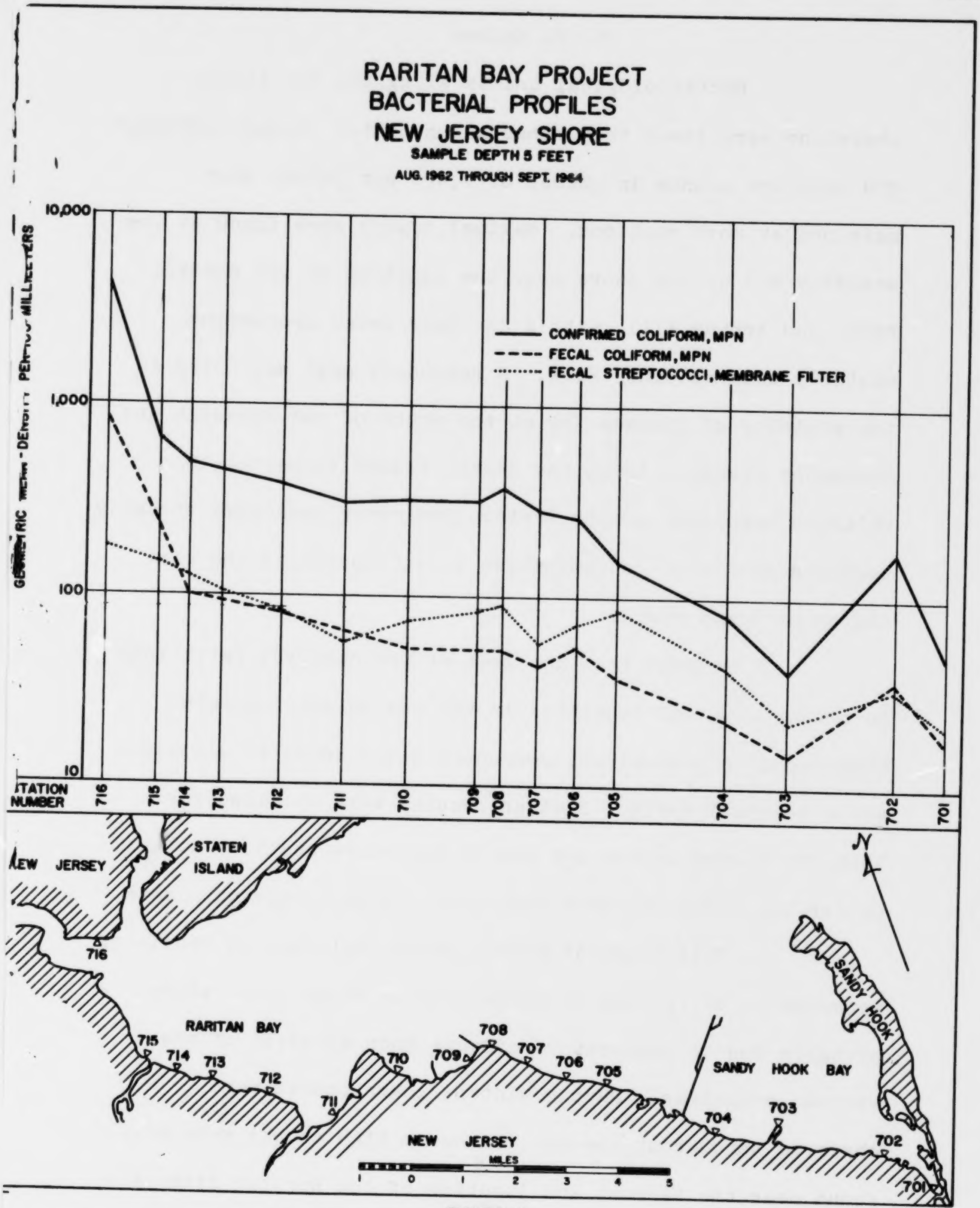


FIGURE II

GPO 956-592

Bacteriological counts along the New Jersey shoreline were lower than those along Staten Island, although MPN coliform counts in excess of 2,400 per 100 ml were obtained at most stations. Maximal counts were found at the westerly end of the shore near the junction of the Raritan River and Arthur Kill, with a decrease noted proceeding easterly towards Sandy Hook. A secondary peak was noted in the vicinity of Station 702 at the mouth of the Navesink and Shrewbury Rivers. As on the Staten Island shoreline, the relative magnitude of the various indicator organisms strongly suggests that this contamination is attributed to the discharge of human wastes.

Mathematical analyses of the observed variations in bacteriological densities in the bay waters indicated that the most predominant component which could be explained was a seasonal cycle. Similar results were obtained for both the Staten Island and New Jersey shore stations as well as for the effluents from municipal sewage treatment plants.

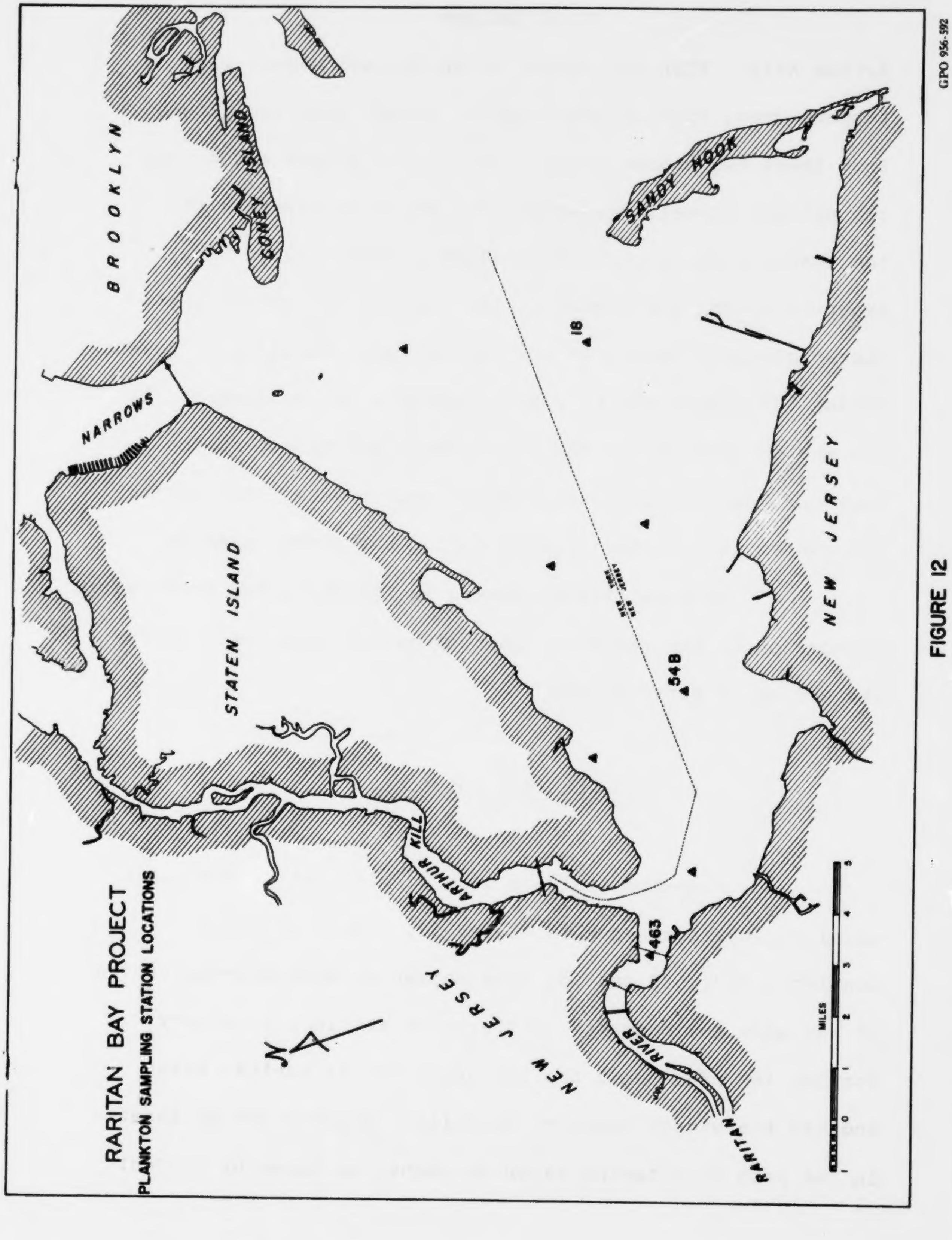
This seasonal effect on bacteriological densities appeared to be related to variations in water temperature, probably due to temperature effects upon survival of the various organisms. During winter, lower counts were observed throughout the bay, although high counts were still found near the Narrows and junction of the Raritan River and

Arthur Kill. With the advent of spring and warmer water temperatures, high bacteriological counts radiated outwards from these two source areas. During the summer and autumn the pattern closely resembled that shown in Figure 8 for the yearly mean, except that slightly lower counts were observed during the summer at the western end of the bay. Bacteriological counts in the Narrows were found to be lowest during the spring and to reach a maximum in the summer. At the western end of the bay the reverse was true. At the mouth of the Raritan River maximum counts were found during the winter with minimal counts during the summer season.

No significant changes in the above bacteriological pattern or in the observed range of values were noted during the period of surveillance.

Plankton and Nutrients

Plankton analyses were carried out at the eight sampling stations shown in Figure 12. Three of these stations, 463, 54B and 18, were chosen as most representative of the wide environmental differences within the estuary. Station 463 represents the influence of the Raritan River and had the widest range of salinity. Station 54B is located in the path of outgoing water movement, as shown by Project


BROOKLYN
CONEY ISLAND
NARROWS
STATEN ISLAND
ARTHUR KILL
SANDY HOOK
NEW YORK
NEW JERSEY
NEW JERSEY
NEW JERSEY
RARITAN RIVER
18
54B
463
MILES
0
1
2
3
4
5
N

RARITAN BAY PROJECT
PLANKTON SAMPLING STATION LOCATIONS

FIGURE 12

GPO 956-592

dye studies, and hence would be readily affected by pollution sources in the western end of the bay. Station 18 near Sandy Hook is farthest removed from known pollution sources, and it is where the more oceanic waters enter Raritan Bay.*

The seasonal variation and abundance of phytoplankton at these three stations is shown in Figure 13. With one exception, total cell numbers exceeded 10,000 per ml; highest cell densities occurred during July and August. The greatest phytoplankton density was found at Station 54B, represented by the solid line on the graph.

During the period of study nanoplankton comprised 94 percent or more of the total phytoplankton population. At all stations the nanoplankton population was high during the summer and low in the winter. (Nanoplankton blooms developed as water temperatures increased sharply in May and June and showed peak densities coincident with peak water temperatures.) During summer blooms nanoplankton comprised as much as 99.9 percent of the total plankton population.

Netplankton blooms occurred during the colder months, disappearing as temperatures reached 8 or 9°C; hence, netplankton densities were lowest during the summer and greatest in the spring. At their peak, spring blooms of

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*Jeffries 1962

TOTAL PHYTOPLANKTON VARIATION & ABUNDANCE
3 STATIONS-RARITAN BAY

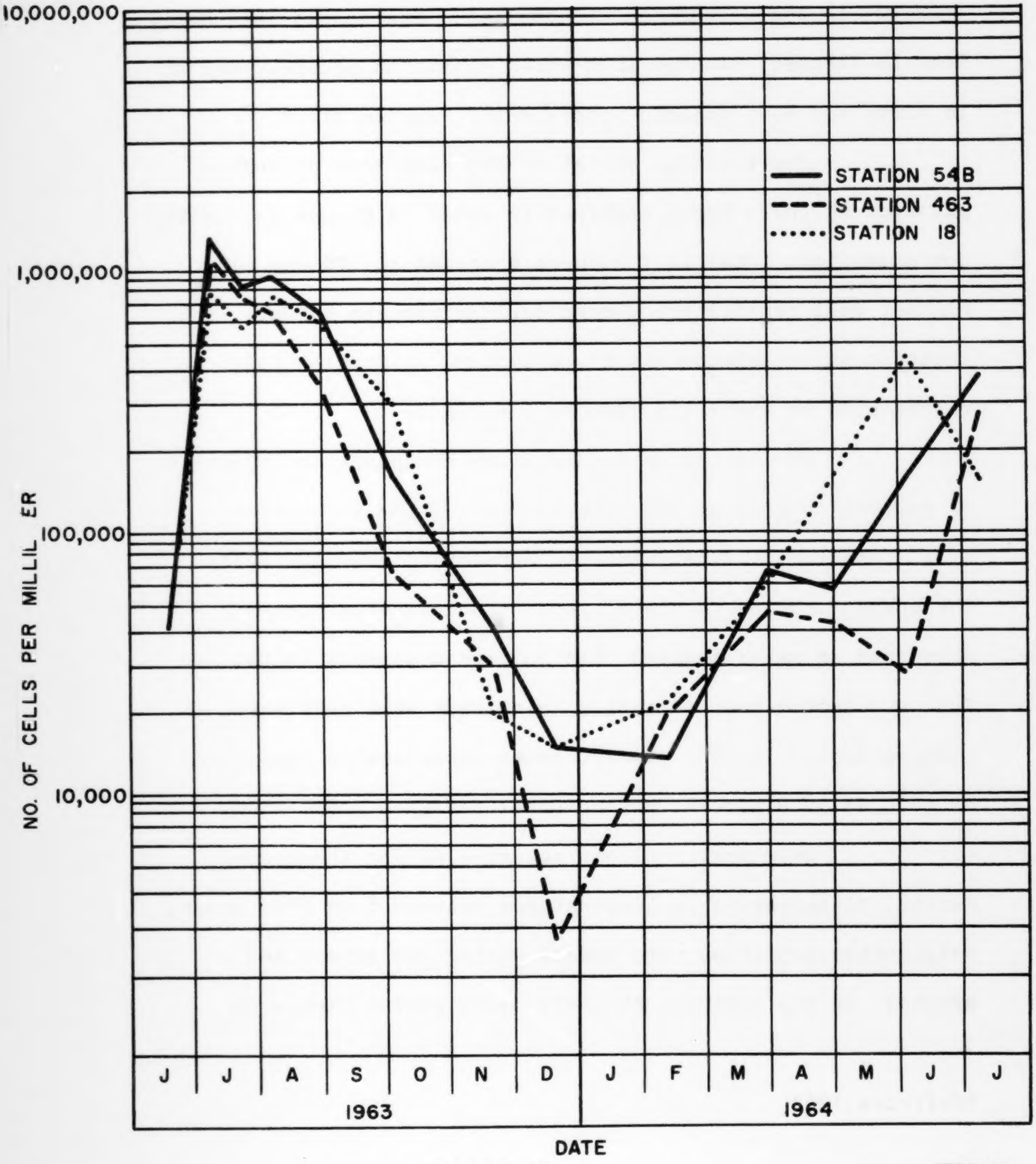


FIGURE 13

netplankton constituted 27 to 48 percent of the total plankton population. In both 1962 and 1963 blooms of netplankton occurred during the first week of October at Station 18. Such fall blooms are a normal occurrence in coastal waters.

Phytoplankton densities during 1963 blooms were twice those found during blooms in 1964, but it was noted that water temperatures in 1963 were 1 to 2°C higher at the time of the peak bloom.

Phytoplankton populations were dominated by two algal species, Nanochloris atomus and Skeletonema costatum. The former, a green alga, comprised more than 50 to 99.9 percent of the nanoplankton community. Skeletonema costatum, a diatom, comprised from less than 1.0 to more than 99 percent of the netplankton population. During August and September 1962, and again in 1964, a dinoflagellate, Peridinium trochoidum, numerically dominated the netplankton population. This alga was not observed in quantitative samples collected during the summer of 1963.

In quantitative samples, no more than 20 different phytoplankters were observed at any one station at one time. The maximum number of species occurred in late spring, while minimal numbers were found in autumn. Generally, fewer species were found towards the western end of the bay than in the seaward end. Occasionally, a fresh water species was observed at all stations.

Large numbers of zooplankton were found from Novemher 1963 to August 1964. In general, zooplankton density decreased from Station 18 to Station 463. Maximum density variation was observed at Station 54B. Zooplankton densities exhibited seasonal patterns paralleling both water temperature and blooms of netplankton. The plentiful supply of phytoplankton from such blooms enabled the zooplankton population to achieve high densities.

A small crustacean, the copepod, comprised 72 percent of the total zooplankton, with the predominant genus being Arcartia, which is a true estuarine organism. Other major components of the zooplankton population were found to be rotifers and larval benthos. During December 1963, 38 percent of the total zooplankton population at both Station 463 and 54B was formed by a rotifer commonly found in the Raritan River. In June 1964, a different rotifer, presumably from both the Raritan River and Arthur Kill, comprised 74 percent of the zooplankton population at Station 54B, 6 percent of that at Station 18, and was present at Station 463, thus indicating an outward movement of this organism during the summer months. Both copepods and rotifers were found in concentrations in excess of 100,000 per cubic meter. In late May and early June 1964, juvenile copepods of the

Arcartia genus appeared in densities of approximately 100,000 per cubic meter, resulting in a red appearance of the surface water of inner Raritan Bay.

Coincidental with plankton studies, levels of selected nutrients were determined at each of the plankton stations. Results of these analyses are presented in Table XI. These selected nutrients were always present in amounts sufficient to support the observed plankton populations. Nutrient levels were generally highest at Station 463 and lowest at Station 18. High concentrations of phosphate were found at Station 54B, while Station 463 showed nitrite and nitrate concentrations higher than the other stations.

Benthic Studies

During 1963 and 1964 benthic samples were collected in Raritan Bay and were subjected to both chemical and biological analyses. During the summer of 1963, one benthos sample was collected at each of the stations shown in Figure 14. The bottom sediment was classified according to median grain size. Those stations with sediment composed of the smallest size particles had fewer animals than those areas with the larger grain size.

The bay area was divided into the five sections shown in Figure 14. Section A was designated as the pollution source area and Sections B, C, D and E were located respectively 0.5, 1.0, 2.0, and 5.0 miles from Section A. The only median grain size found common to all sections was the 30 micron or smaller category. Figure 15 presents the average density of benthic organisms and the number of different species found in each section. For all median grain size categories the number of individuals and the number of species increased progressively with distance from Section Act.

During 1964, benthic studies were made utilizing only those stations with sediment having a median grain size of 30 microns or less. Figure 16 shows the location of the stations utilized. Stations 61, 62 and 65 were located in the most polluted area of the bay. Stations R, B, and 29 in less polluted areas. Stations H and 15, located in an area open for commercial shellfishing, were in relatively clean water.

Results in 1964 confirmed those of the previous year as progressively more species were found with increasing distance from the western end of Raritan Bay. The number of species in polluted areas were markedly fewer than in those areas regarded as non-polluted. Figure 17 shows the pattern of progressive colonization moving westerly across the bay between February and August. In February 1964, benthic animals were found only at the three outermost stations -- 29, H and 15; by August all stations had become populated. During the same period there was an increase in both temperature and chlorinity paralleling this progressive colonization. The density of organisms displayed a pattern similar to that for the total number of species found. More organisms were found farthest away from Stations 62, 65 and 61, with the exception of August 1964, when quantities of the softshell clam, Mya arenaria -- a highly pollution tolerant organism -- were found at Stations 62 through B.

The types of benthic organisms and their relative numbers are presented in Table XII. The polychaete, or segmented worms and anthropod crustaceans were the dominant benthic organisms. Tube dwelling worms, regarded as pollution tolerant organisms, were more numerous towards Stations 62 and B, indicating a greater degree of pollution in that area.

In May and August 1964, certain chemical analyses were performed on samples of bottom sediment. A comparison was made between these data and the average number of benthic species found at each station. With the exception of Station H the results presented in Figure 18 indicate a general decline in the level of Total Kjeldahl Nitrogen, BOD and COD with increasing distance from the more polluted stations. The higher concentrations at H were attributed to a small sewer outfall located in the immediate vicinity. In general, fewer benthic species were found at those stations having the higher concentrations of nitrogen.

Color and Turbidity

The color of water in Raritan Bay was found to be frequently associated with dominant phytoplankton populations. During the summer of 1963, for example, the predominant alga *Nanochloris* imparted a turf grass green color to the water. During the late winter and spring the water was a brownish color due to an abundance of a diatom, *Skeletonema costatum*. In July 1964, the water of the inner part of Raritan Bay had a reddish color due to an abundant flagellate growth.

Turbidity at three stations in Raritan Bay, as measured by Secchi disc transparency, is illustrated in Figure 19. Turbidity appeared to be independent of plankton density and was due mainly to large amounts of detritis.

TABLE XI

RARITAN BAY NUTRIENTS

Station	463			54B			18		
1963	NO_2^- N	NO_3^- N	PO_4 *	NO_2^- N	NO_3^- N	PO_4^- P	NO_2^- N	NO_3^- N	PO_4^-* P
Mar.	--	0.65	0.14	--	--	--	--	0.39	0.06
Apr.	--	0.15	0.07	--	0.07	0.26	--	--	--
May	0.06	0.34	0.11	--	0.21	0.10	0.02	0.11	0.09
June	0.08	0.44	0.15	0.07	0.27	0.14	0.04	0.16	0.08
July	0.10	0.19	0.14	0.04	0.07	0.18	0.02	0.05	0.13
Aug.	0.11	0.16	0.19	0.06	0.09	0.24	0.04	0.05	0.17
ept.	0.20	0.44	0.06	0.06	0.18	0.18	0.04	0.14	0.16
Nov.	0.07	0.49	0.14	0.08	0.50	0.12	0.07	0.39	0.13
1964									
May	0.04	0.08	0.12	0.03	0.07	0.11	0.02	0.09	0.13
June	0.07	0.13	0.14	0.06	0.06	0.15	--	--	--
July	0.10	0.27	0.16	0.06	0.15	0.16	0.03	0.05	0.14
Nov.	0.09	0.43	0.24	0.12	0.25	0.24	0.07	0.04	0.22
Av.	0.09	0.31	0.14	0.06	0.17	0.17	0.04	0.15	0.13

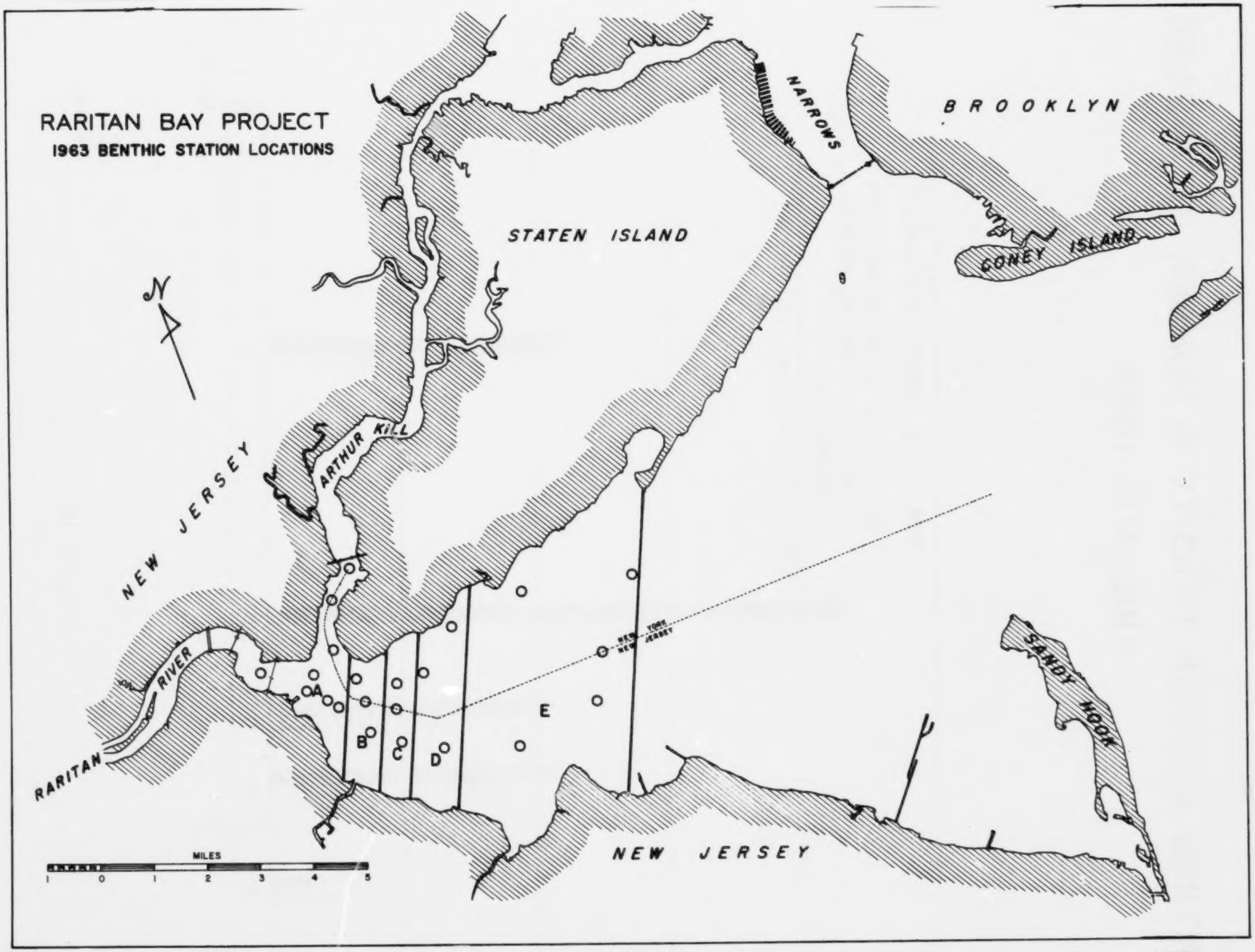
* Phosphate = ortho & poly (soluble)

TABLE XII

PERCENTAGE OF BENTHOS AT REPRESENTATIVE STATIONS

	Station 62				Station B				Station 29				Station H			
1964	PW	AC	SC	O	PW	AC	SC	O	PW	AC	SC	O	PW	AC	SC	O
Feb.	0	0	0	0	76	6	0	18	67	17	0	16	8	92	0	0
May	100	0	0	0	65	15	0	20	33	66	0	1	15	85	0	0
Aug.	0	0	100	0	35	28	10	27	74	19	7	0	55	38	0	7

PW = Polychaete Worms
AC = Amphipod Crustaceans
SC = Soft Shell Clams
O = Others: All types of organisms that comprised separately less than 5% of the total.



RARITAN BAY PROJECT
1963 BENTHIC STATION LOCATIONS

STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
NEW YORK
NEW JERSEY
A
B
C
D
E
N
MILES
1
0
1
2
3
4
5

FIGURE 14

BENTHOS AVERAGE DENSITY & NUMBER OF SPECIES
JUNE-AUG. 1963

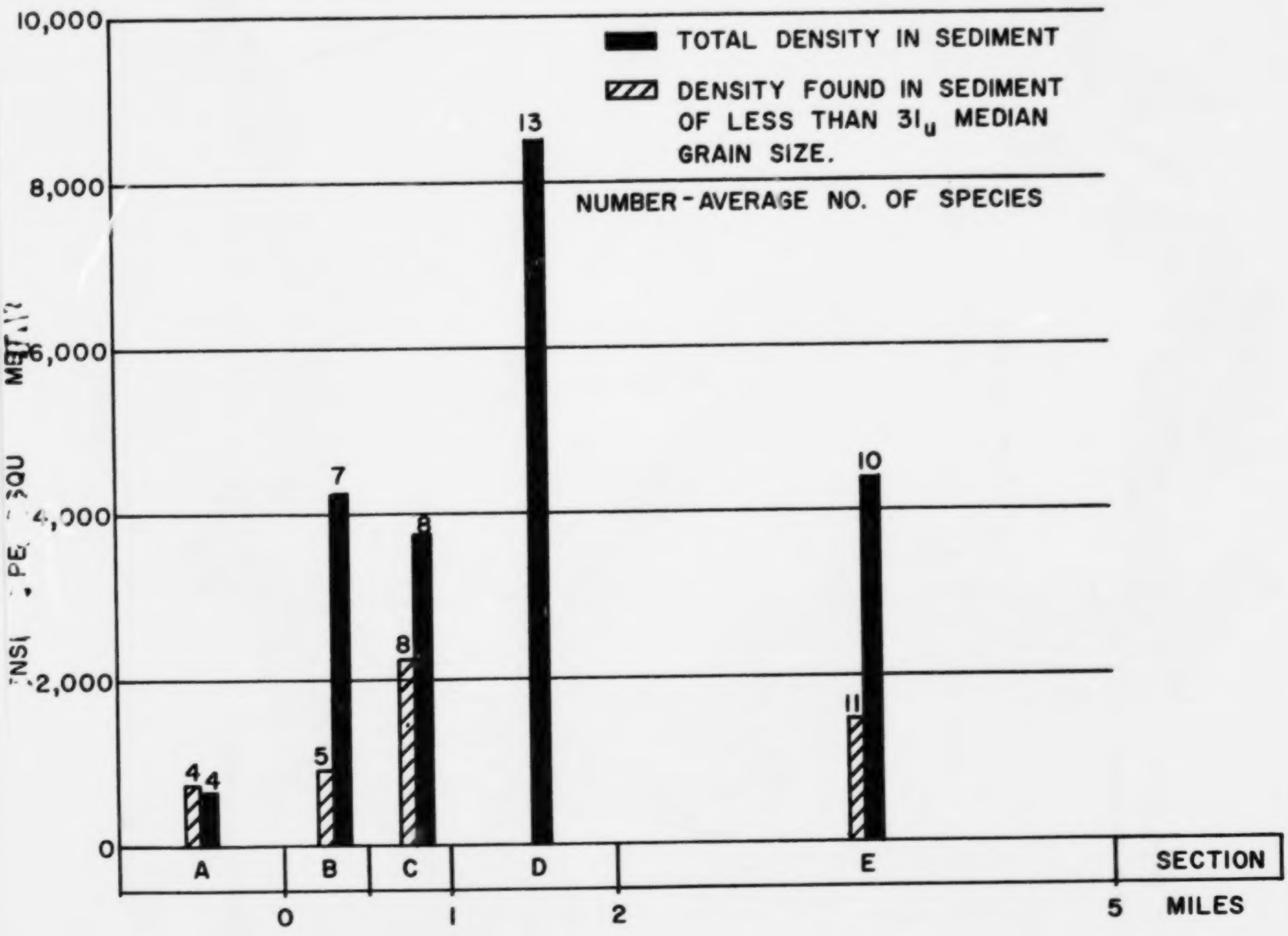
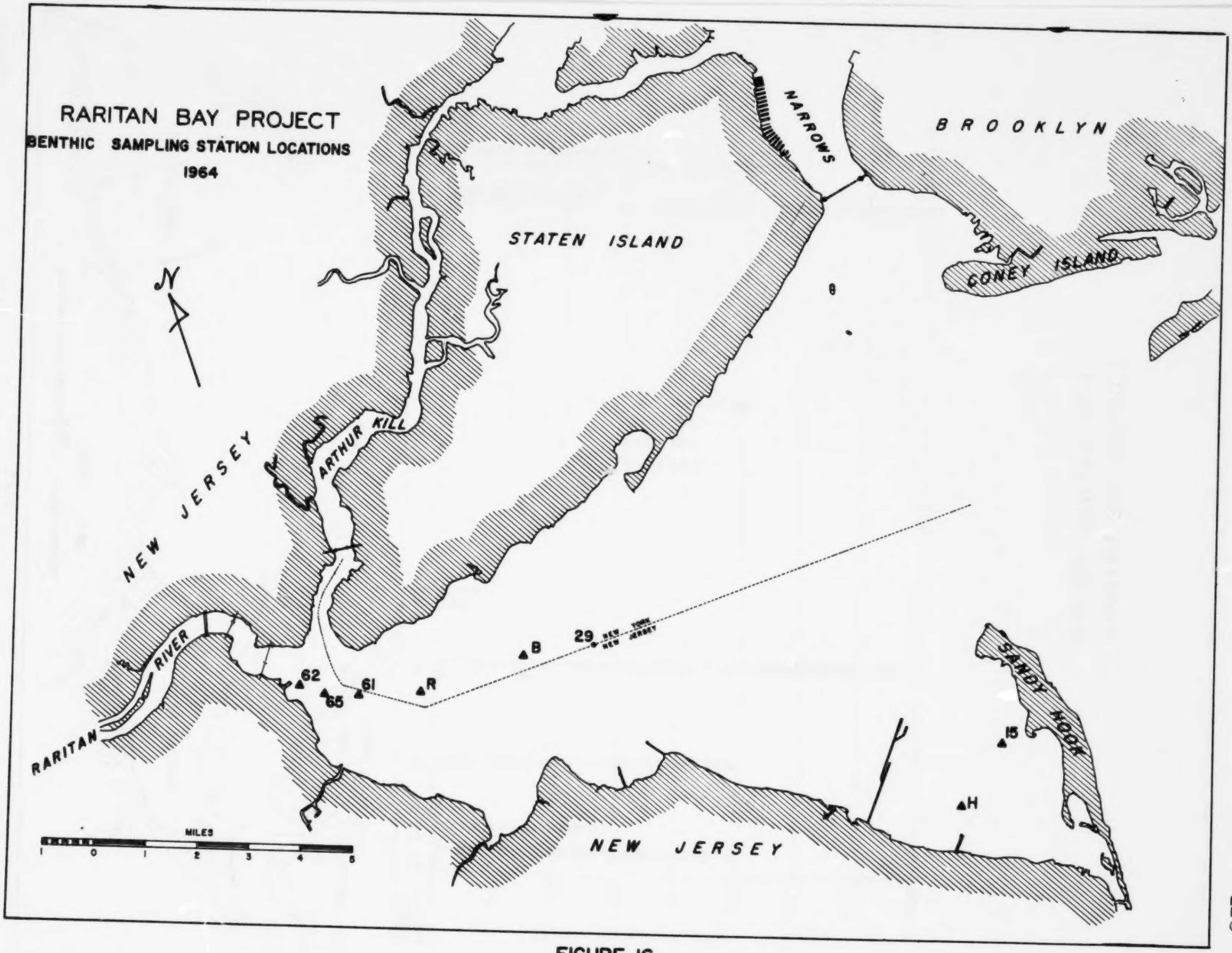


FIGURE 15



RARITAN BAY PROJECT
BENTHIC SAMPLING STATION LOCATIONS
1964

N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
NEW JERSEY
ARTHUR KILL
RARITAN
RIVER
62
65
61
R
B
29
NEW YORK
NEW JERSEY
SANDY HOOK
15
H
NEW JERSEY
MILES
1
0
1
2
3
4
5

FIGURE 16

RARITAN BAY PROJECT
BENTHIC DENSITY 1964

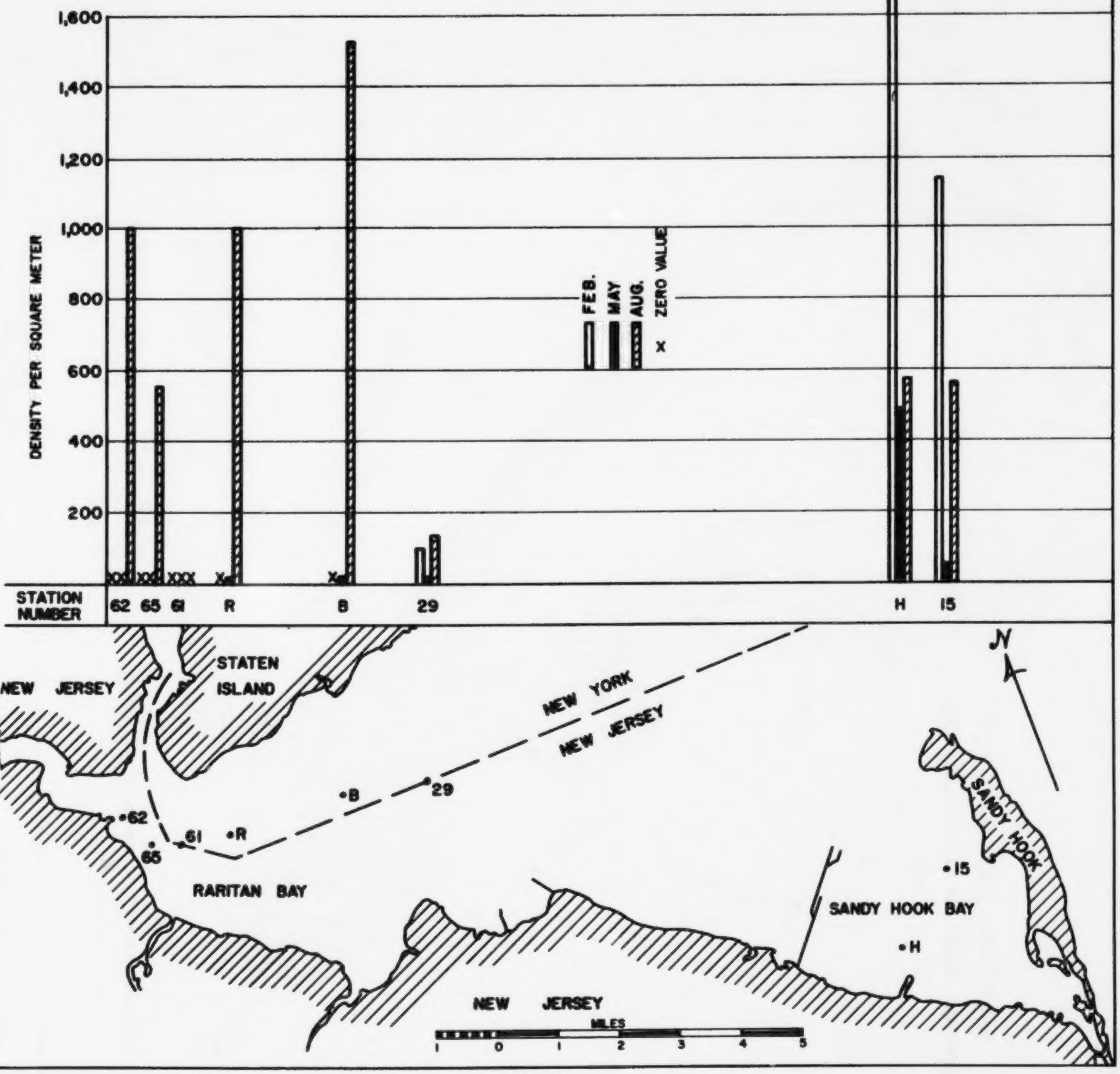


FIGURE 17

RARITAN BAY PROJECT
CHEMICAL & BIOLOGICAL SEDIMENT ANALYSIS
MAY AND AUGUST 1964

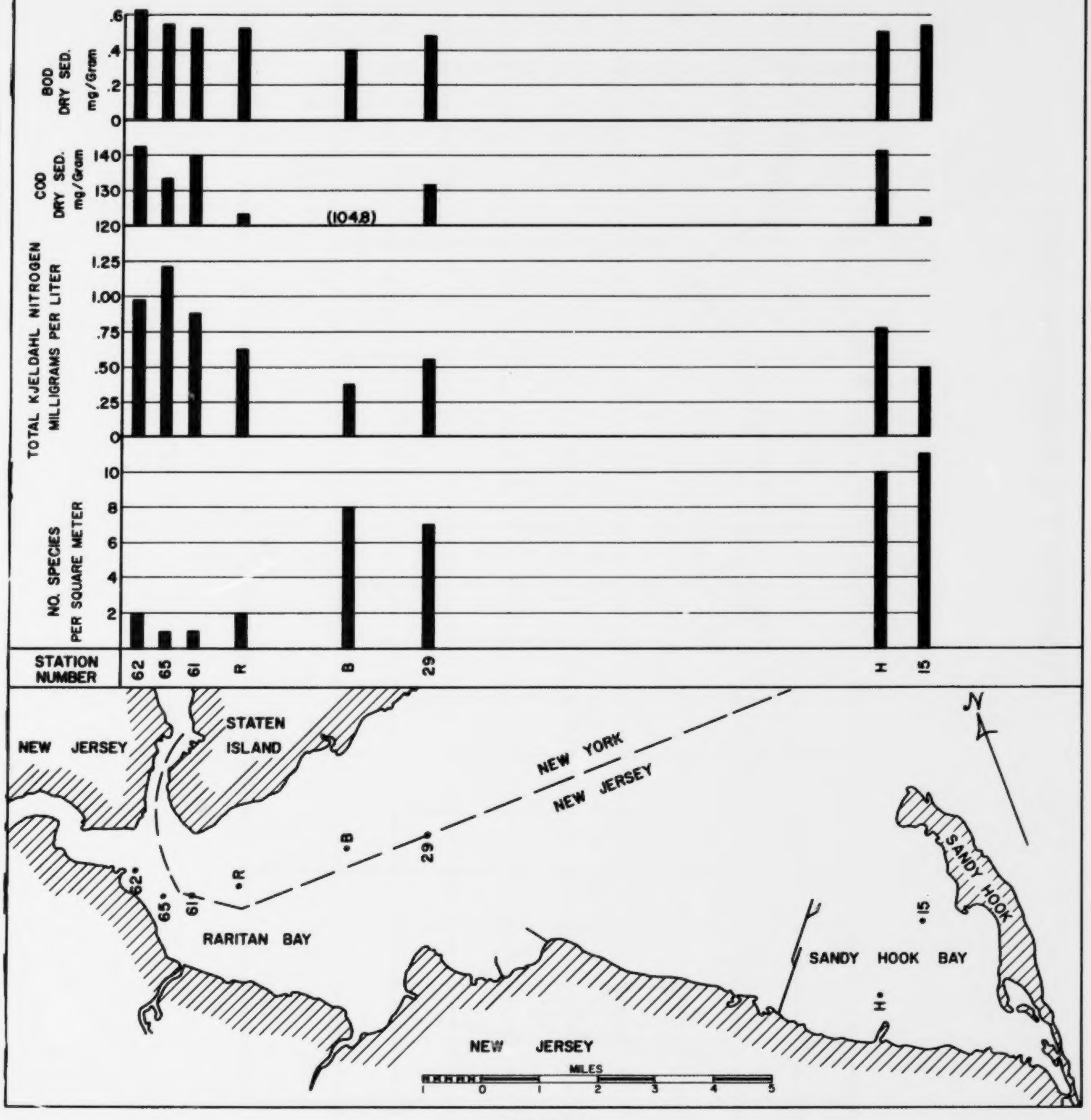


FIGURE 18

TURBIDITY, RARITAN BAY

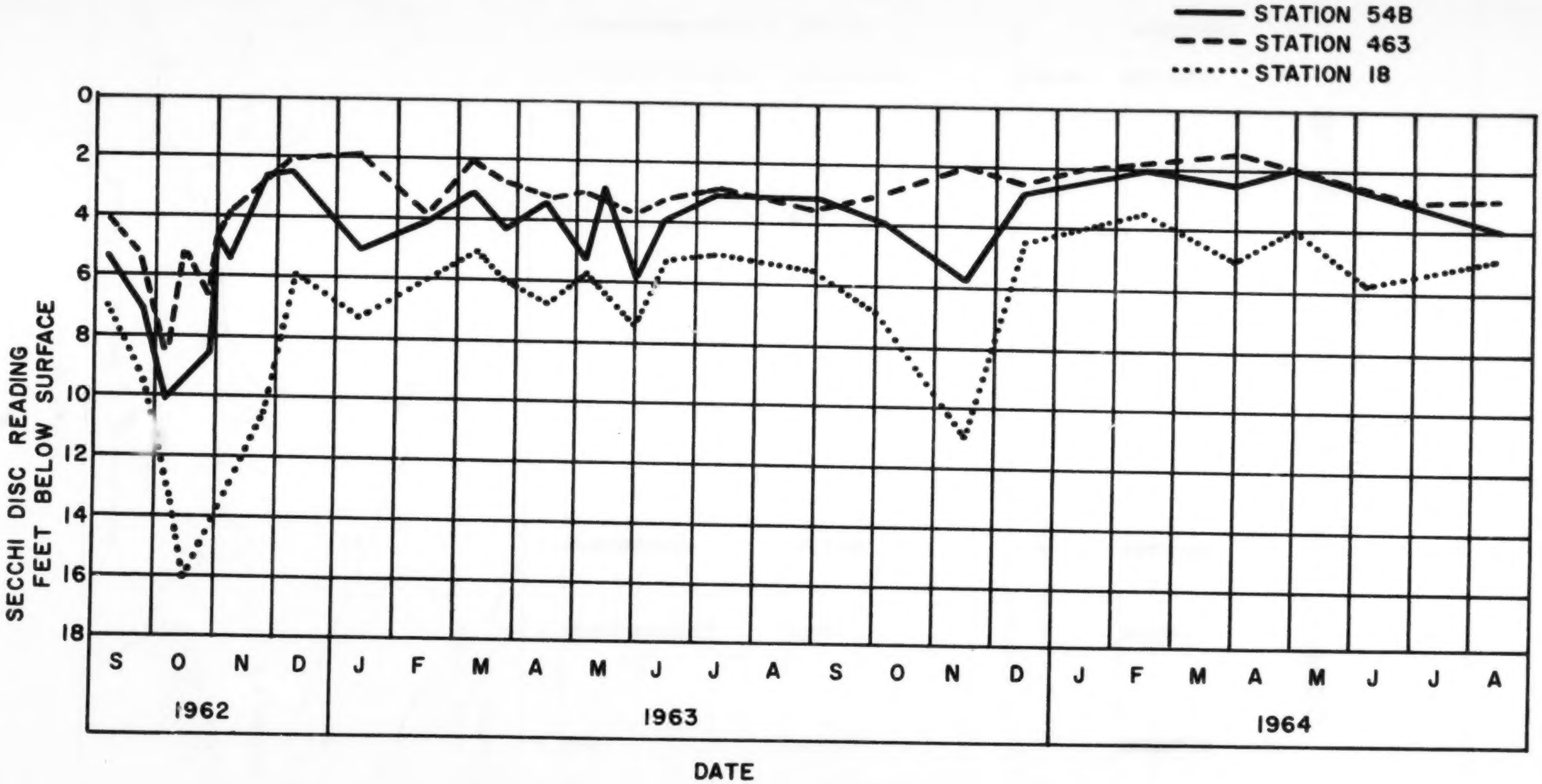


FIGURE 19

GPO 956-592

Arthur Kill

Water Temperature

Average water temperatures ranged from 12 to 16°C, as shown in Figure 20. Temperatures as high as 28°C were observed; maximum water temperatures over the entire length of the kill were greater than 26°C. The average water temperature declined gradually proceeding north through the kill into Newark Bay -- warmest temperatures were found in the southern portion of the kill.

Chloride

Average chloride concentration at the lower end was 13,500 mg/1. Chlorinity declined proceeding northward with an average value of 11,500 mg/1 at the junction with Newark Bay. From this point to Upper Bay there was an increase in chloride concentration through the Kill Van Kull.

During the surveillance period the same spatial pattern was observed. Slight increases in mean values were noted near the middle reach of the kill. Minima concentrations also increased, but maxima were unchanged. These observed changes may be explained by a decrease in fresh water runoff due to the prolonged drought period.

BOD_5

Average BOD concentrations ranged from 3 mg/1 at Outerbridge Crossing to 6 mg/1 north of Station 502, which is located near the center of the kill. At the junction of the kill and Newark Bay, BOD values decreased to 3 mg/1. Maximum BOD values of 12 mg/1 were found near the center of the kill.

Analyses of BOD at increasing dilutions indicated an apparent toxic effect upon the exertion of BOD in the kill. Hence, results are not completely indicative of the oxygen demanding load. The presence of large quantities of phenols may account for this apparent inhibition of BOD exertion.

Because of this observed toxicity, COD was substituted for BOD during the surveillance operations.

COD

Results of analyses for chemical oxygen demand on the Arthur Kill are presented in Figure 21. Average COD values throughout the kill ranged from 110 to 135 mg/1.

During the surveillance period no significant change was observed in the levels or spatial pattern for COD.

Dissolved Oxygen

The average dissolved oxygen concentrations during the intensive sampling period of August 1962 through September 1963 are presented in Figure 22. Average concentrations of 6 mg/1 were found at Outerbridge with a decline to an average of 2.5 mg/1 from Stations 503 to 520 in the center, and a recovery to 3.5 mg/1 at the entrance to Newark Bay. Minimum values were zero from Stations 504 to 507, in the upper kill from the mouth of the Elizabeth River to Newark Bay.

Studies were undertaken to determine the net effect of photosynthetic production of oxygen (See Figure 23). Total oxygen uptake at Station 503 significantly reduced the net oxygen yield from photosynthesis. At Station 505 more oxygen was utilized than could be produced by photosynthesis. Oxygen production was insignificant below eight feet. On a total basis more oxygen was produced by photosynthesis in Arthur Kill than in Raritan Bay. Oxygen uptake in the kill was three times greater than in the bay, resulting in a net apparent yield of oxygen in the kill of only one-tenth of that found in Raritan Bay. Only 5.0 percent of the total oxygen produced by photosynthesis in the Arthur Kill was available to the water.

Additional studies were conducted to determine the effect of commercial dredging on dissolved oxygen concentrations. On two separate occasions measurements were taken during dredging operations (See Figure 24). Dissolved oxygen levels were lowest at the dredging site and lower in the vicinity of the dredging operation than elsewhere in the kill. The average dissolved oxygen concentrations for non-dredging periods between December 1963 and March 1964 were higher than those noted during dredging.

Surveillance of the kill indicates a continued decline in dissolved oxygen levels. Mean concentrations were reduced to 1.1 mg/1 near Station 520 about midpoint of the kill, with recovery to only 2.6 mg/1 at Newark Bay. Minima of less than 0.5 mg/1 were observed from Outerbridge to Kill Van Kull.

Phenol

Concentrations of phenolic-type compounds as high as 800 ppb were found in the vicinity of Fresh Kills and the Rahway River. Phenol values in the middle reach of the kill were two to three times greater than the levels found at the

During the surveillance period no significant change was observed in the levels or spatial pattern for COD.

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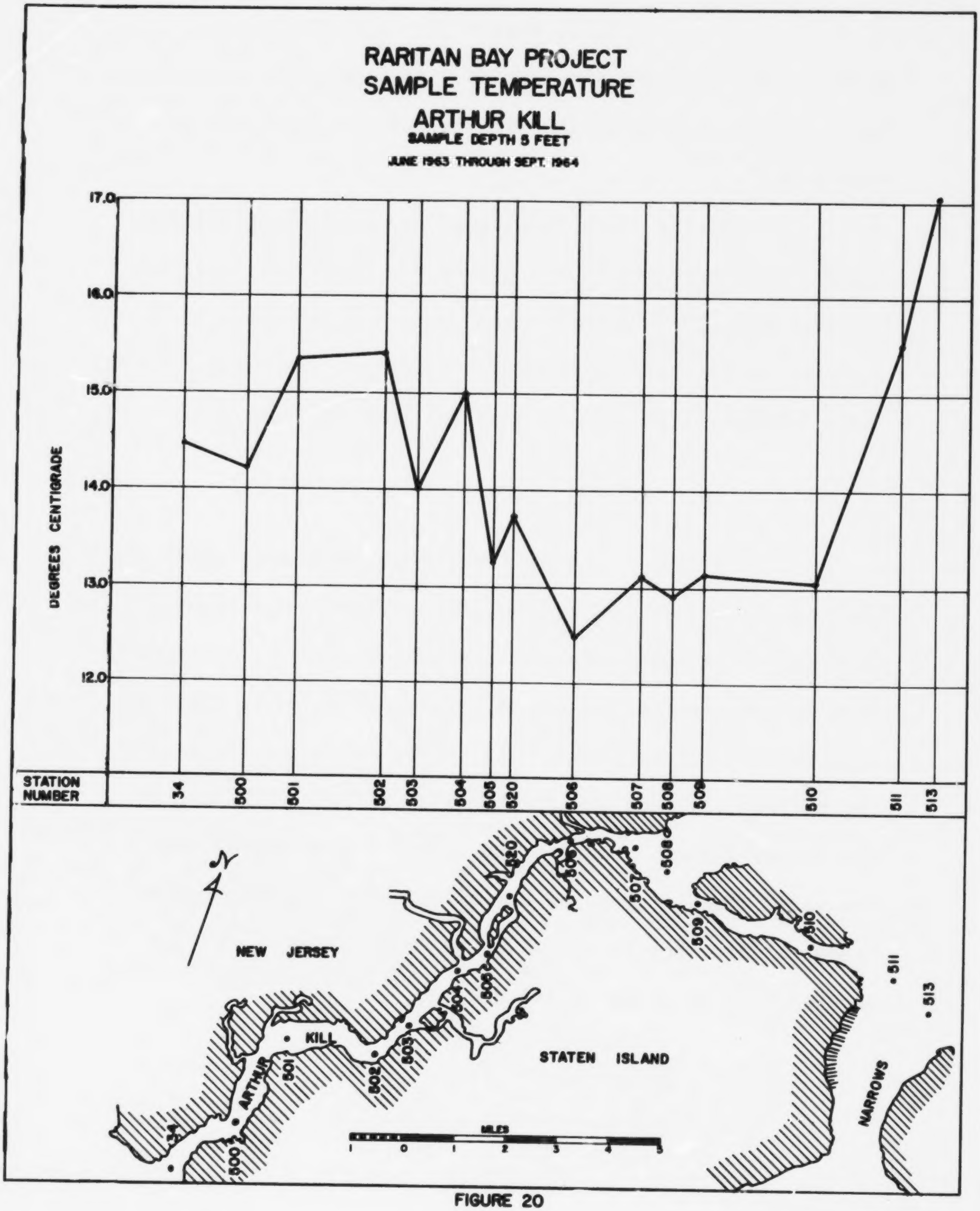
Phenol

Concentrations of phenolic-type compounds as high as 800 ppb were found in the vicinity of Fresh Kills and the Rahway River. Phenol values in the middle reach of the kill were two to three times greater than the levels found at the northern and southern extremities. Average phenol concentrations for the intensive sampling period are presented in Figure 25.

During the surveillance period mean phenol concentrations increased to 105 ppb at the peak locations near Stations 505 and 520, while mean concentrations near the entrance to Raritan Bay decreased slightly. Minima concentrations increased, while maxima values remained constant.

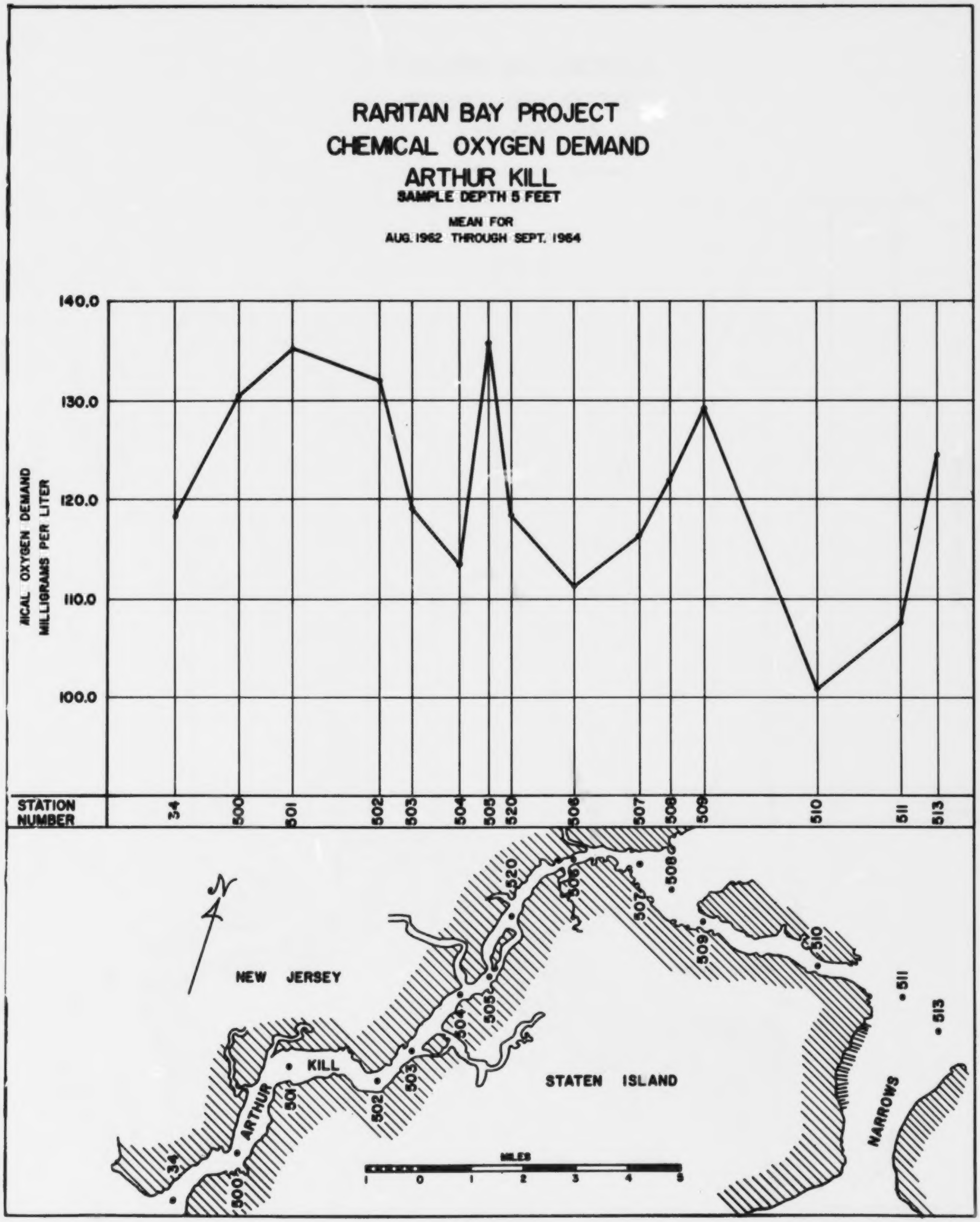
Oil

Although no quantitative analyses were made, oil was frequently observed on the kill surface. Mud samples were collected and an attempt was made to recover oil from this bottom material. Results, presented in Table XIII, indicate a heavy deposit of oil on the bottom of the kill. The maximum oil recovery in the kill was near the mouth of the Rahway River at Station 505, where 1 gram of oil was recovered from 50 grams of dry bottom mud. In Woodbridge Creek, a tributary to the kill, 32 grams of oil were recovered from 50 grams of the dry mud.



RARITAN BAY PROJECT
SAMPLE TEMPERATURE
ARTHUR KILL
SAMPLE DEPTH 5 FEET
JUNE 1963 THROUGH SEPT. 1964

FIGURE 20



RARITAN BAY PROJECT
CHEMICAL OXYGEN DEMAND
ARTHUR KILL
SAMPLE DEPTH 5 FEET

MEAN FOR
AUG. 1962 THROUGH SEPT. 1964

FIGURE 21

RARITAN BAY PROJECT
DISSOLVED OXYGEN
ARTHUR KILL
SAMPLE DEPTH 5 FEET

JUNE 1963 THROUGH SEPT. 1964

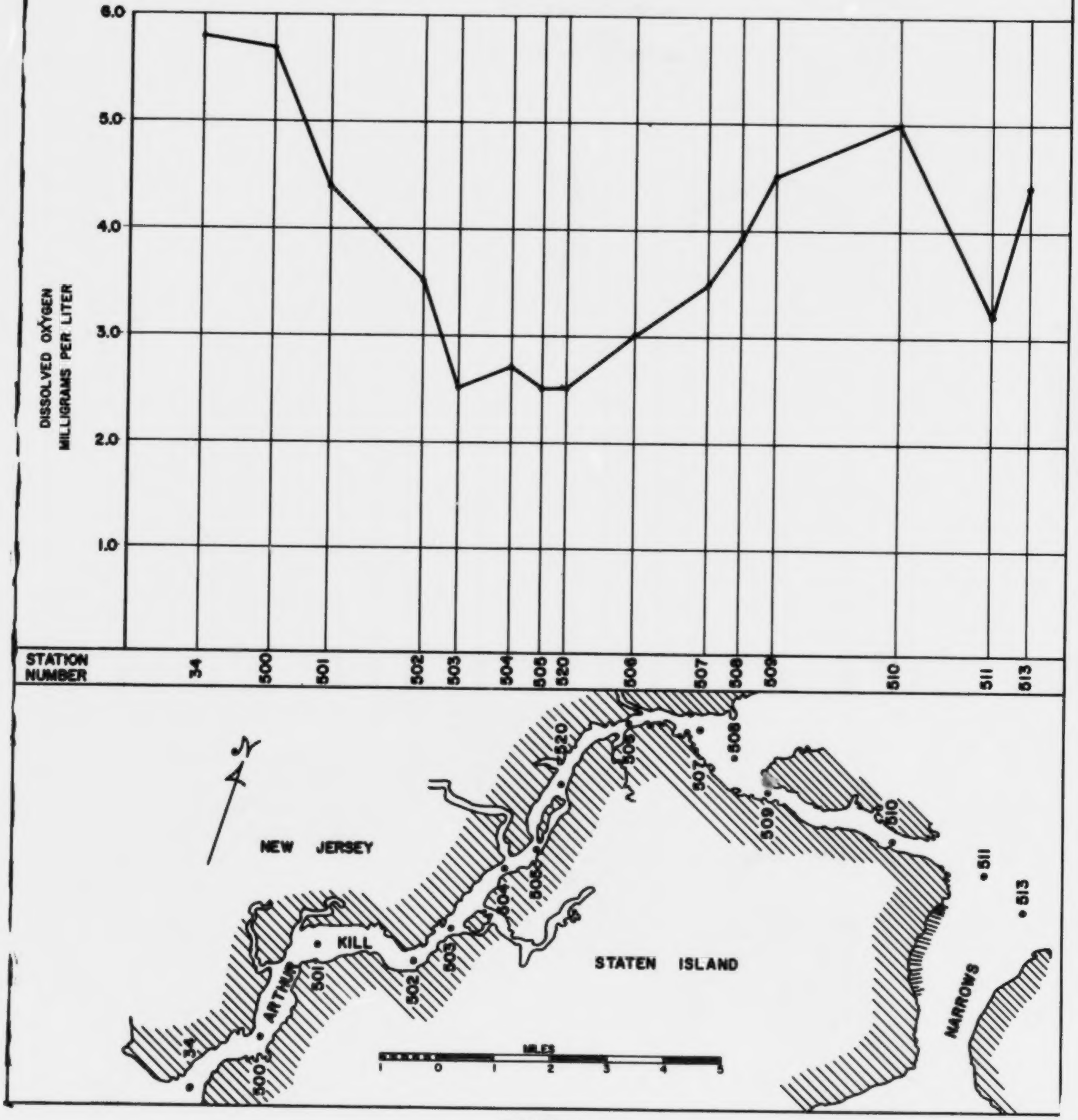


FIGURE 22

OXYGEN PRODUCTION, UPTAKE & YIELD
PHOTOSYNTHETIC ZONE
ARTHUR KILL
AUGUST 1964

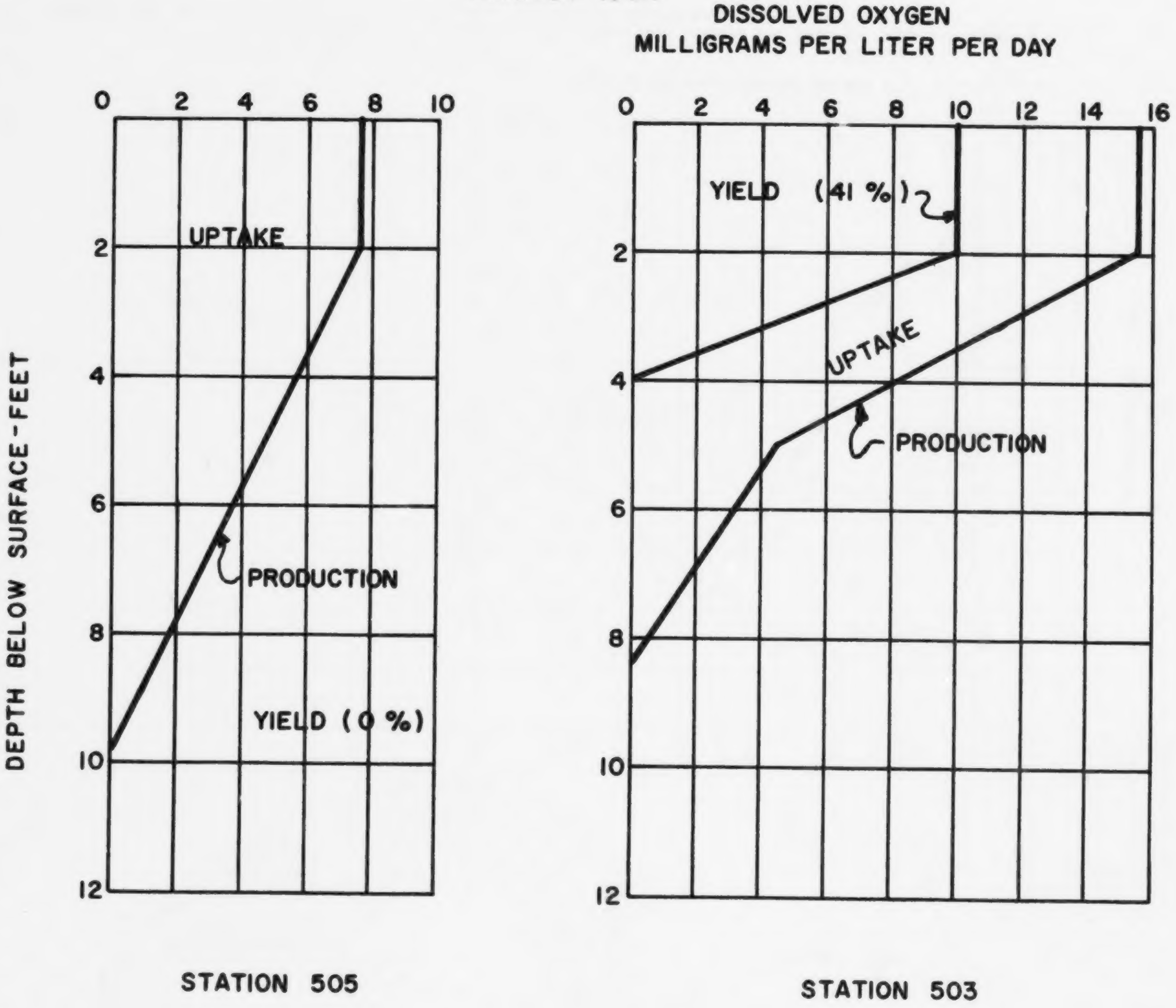


FIGURE 23

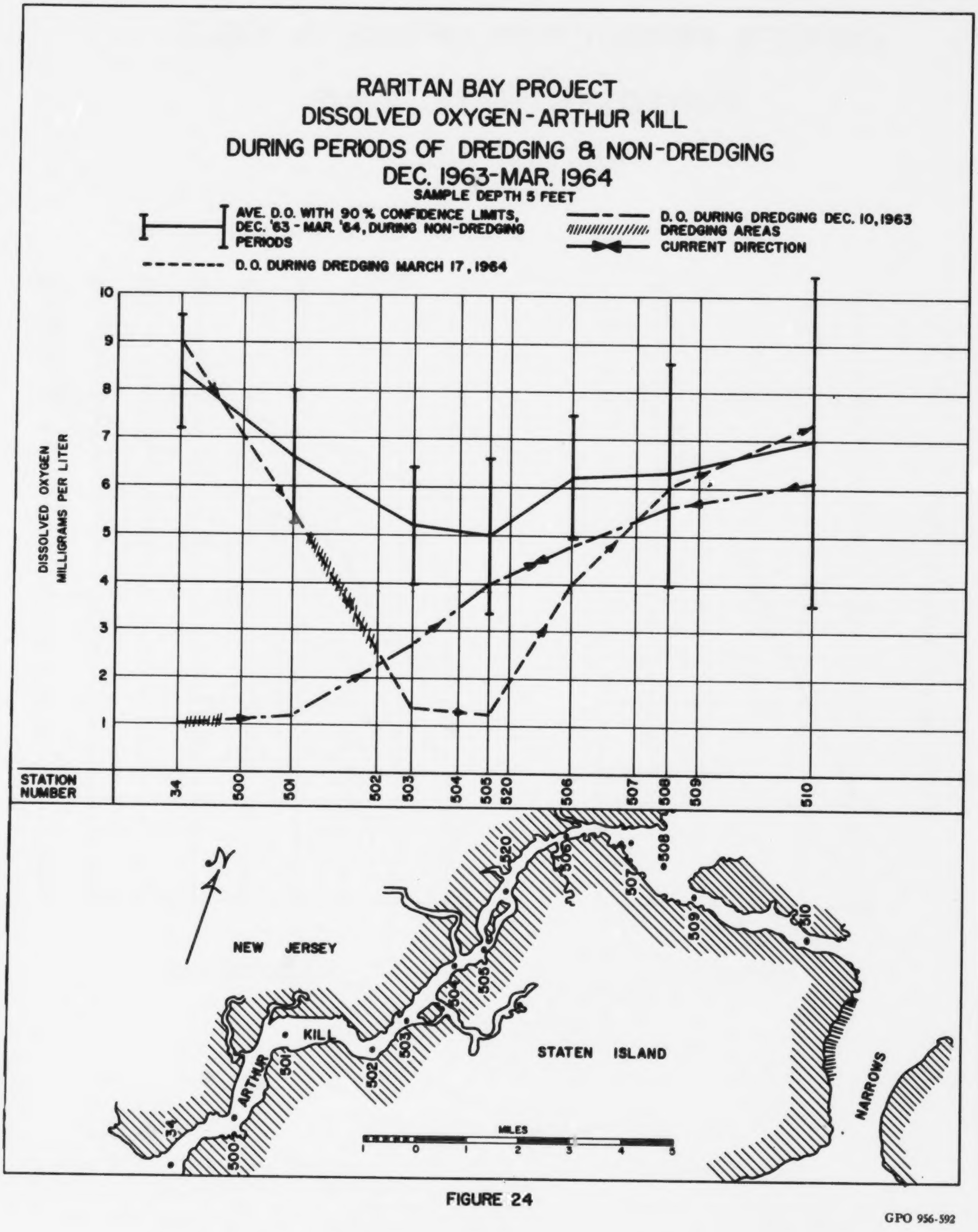

RARITAN BAY PROJECT
DISSOLVED OXYGEN-ARTHUR KILL
DURING PERIODS OF DREDGING & NON-DREDGING
DEC. 1963-MAR. 1964
SAMPLE DEPTH 5 FEET
AVE. D.O. WITH 90% CONFIDENCE LIMITS, DEC. '63 - MAR. '64, DURING NON-DREDGING PERIODS
D.O. DURING DREDGING MARCH 17, 1964
D.O. DURING DREDGING DEC. 10, 1963
DREDGING AREAS
CURRENT DIRECTION
DISSOLVED OXYGEN MILLIGRAMS PER LITER
10
9
8
7
6
5
4
3
2
1
STATION NUMBER
34
500
501
502
503
504
505
520
506
507
508
509
510
N
NEW JERSEY
STATEN ISLAND
ARTHUR
KILL
NARROWS
MILES
1
0
1
2
3
4
5

FIGURE 24

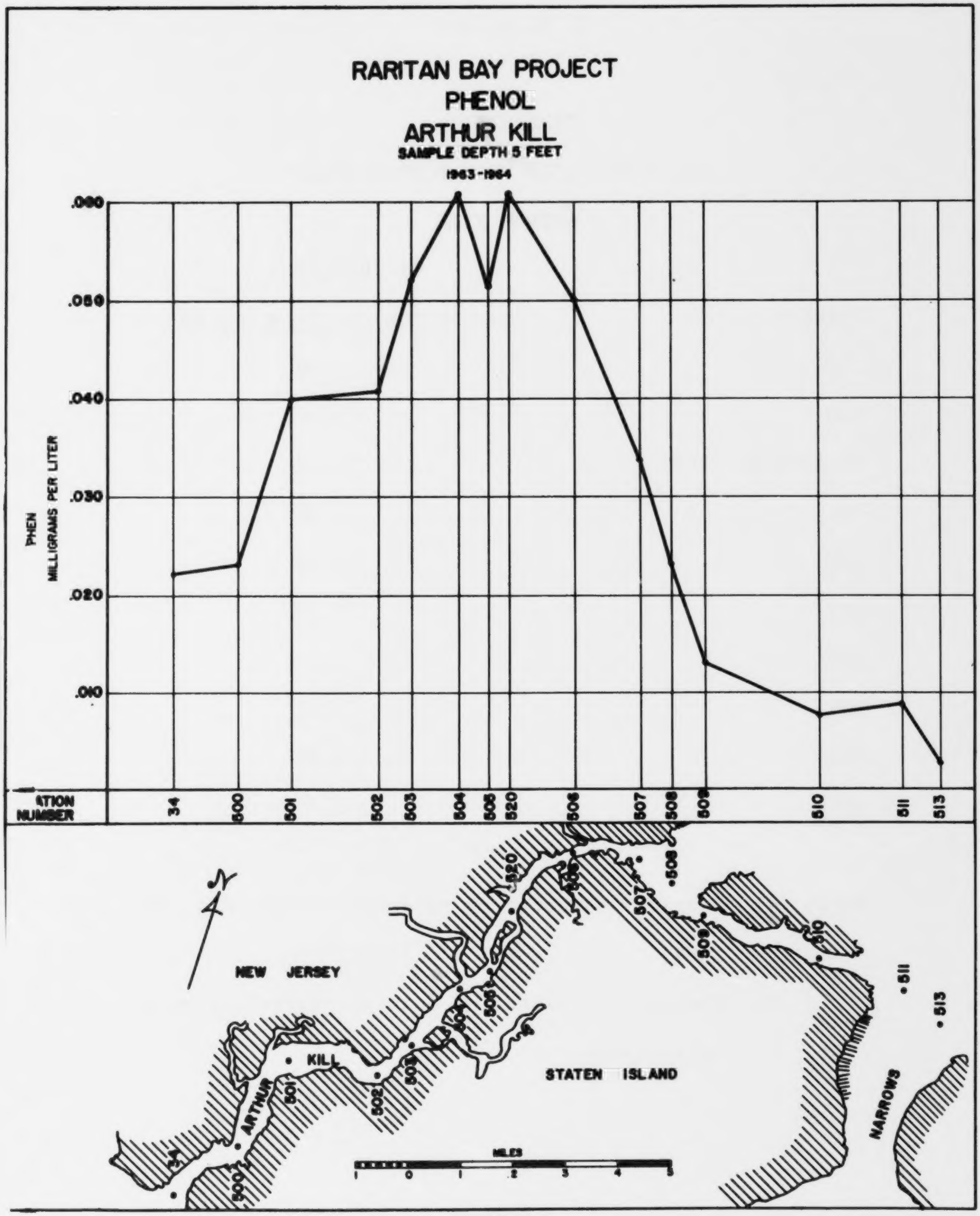
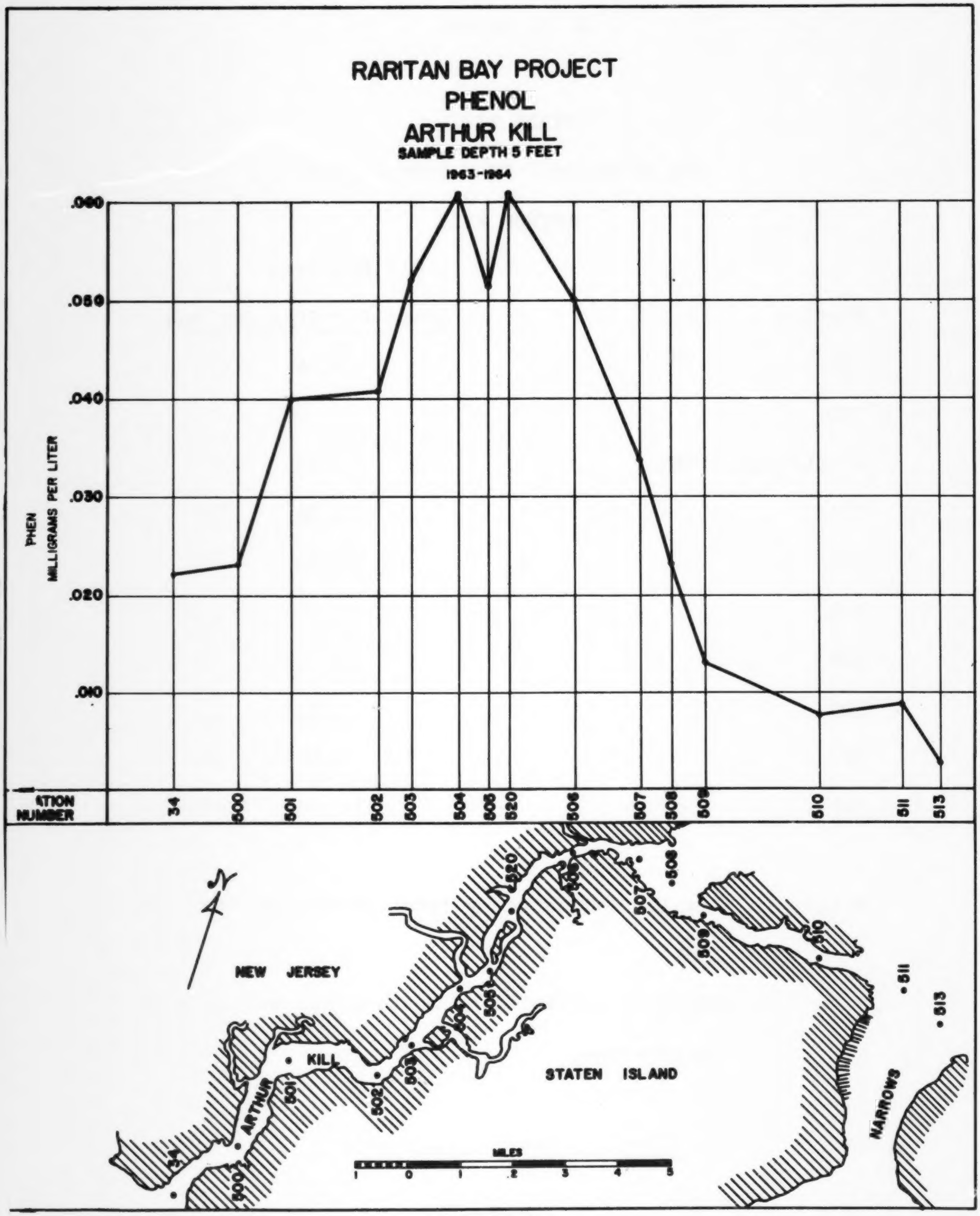

RARITAN BAY PROJECT
PHENOL
ARTHUR KILL
SAMPLE DEPTH 5 FEET
1963-1964
.060
.050
.040
.030
.020
.010
PHEN
MILLIGRAMS PER LITER
ATION NUMBER
34
500
501
502
503
504
505
520
506
507
508
509
510
511
513
N
NEW JERSEY
STATEN ISLAND
ARTHUR
KILL
NARROWS
MILES
1 0 1 2 3 4 5

FIGURE 25



RARITAN BAY PROJECT
PHENOL
ARTHUR KILL
SAMPLE DEPTH 5 FEET
1963-1964

FIGURE 25

TABLE XIII

OIL RECOVERIES FROM BOTTOM MUDS

ARTHUR KILL

Station	Oil Recovery Grams Per 50 g Dry Mud
34	0.04
500	0.08
Woodbridge Creek	31.93
501	0.02
502	0.39
503	0.18
504	0.54
505	1.13
520	0.02
507	0.05

Note:
1. Samples collected by Petersen dredge Sept. 10, 1964.
2. Analysis consisted of Soxhlet extraction with cyclohexane.

Bacteriological Density

Results of limited bacteriological sampling on the Arthur Kill are presented in Figure 26. Total coliform, fecal coliform and fecal streptococcus values indicate severe bacteriological contamination of these waters from human wastes.

During surveillance studies MF coliform showed a slight increase in the reach from Station 503 to Raritan Bay and a decrease in the Kill Van Kull. Fecal coliform values remained within the limits observed earlier, with some reduction in minima values from Station 513 to Station 504.

Plankton and Nutrients

Average phytoplankton density and a comparison of total and net phytoplankton for each station on the kill are presented in Figure 27. Throughout the biological sampling period of October 1963 through September 1964, total phytoplankton density increased progressively from Station 34 to Station 508 and then decreased at Station 510. Net-plankton concentrations at Station 510 were ten times lower than at Station 34. Of the total phytoplankton, nanoplankton comprised 95 percent and characterized the period of maximum density. Netplankton densities were highest during the spring bloom of Skeletonema costatum, the principal netplankton species. During late spring, summer and autumn diatoms of the genus Thallassiosira predominated.

Zooplankton populations are presented in Figure 28. Populations at Stations 503, 505 and 506 were 38 percent less than elsewhere on the Arthur Kill - Kill Van Kull. The number of different species of zooplankton was also reduced at these three stations. Zooplankton populations appeared to be dependent on water temperature and the abundance of phytoplankton rather than chloride concentrations. The majority of zooplankton observed were types able to adjust to wide ranges of salinity. There was a marked increase in the number of zooplankton with the spring and summer period, when an abundant diatom flora and warmer water temperatures appeared. The locational distribution of zooplankton appeared dependent on dissolved oxygen concentrations which would inhibit their growth since zooplankton are active respirators. Lowest zooplankton densities occurred at Station 505 simultaneously with lowest dissolved oxygen concentrations.

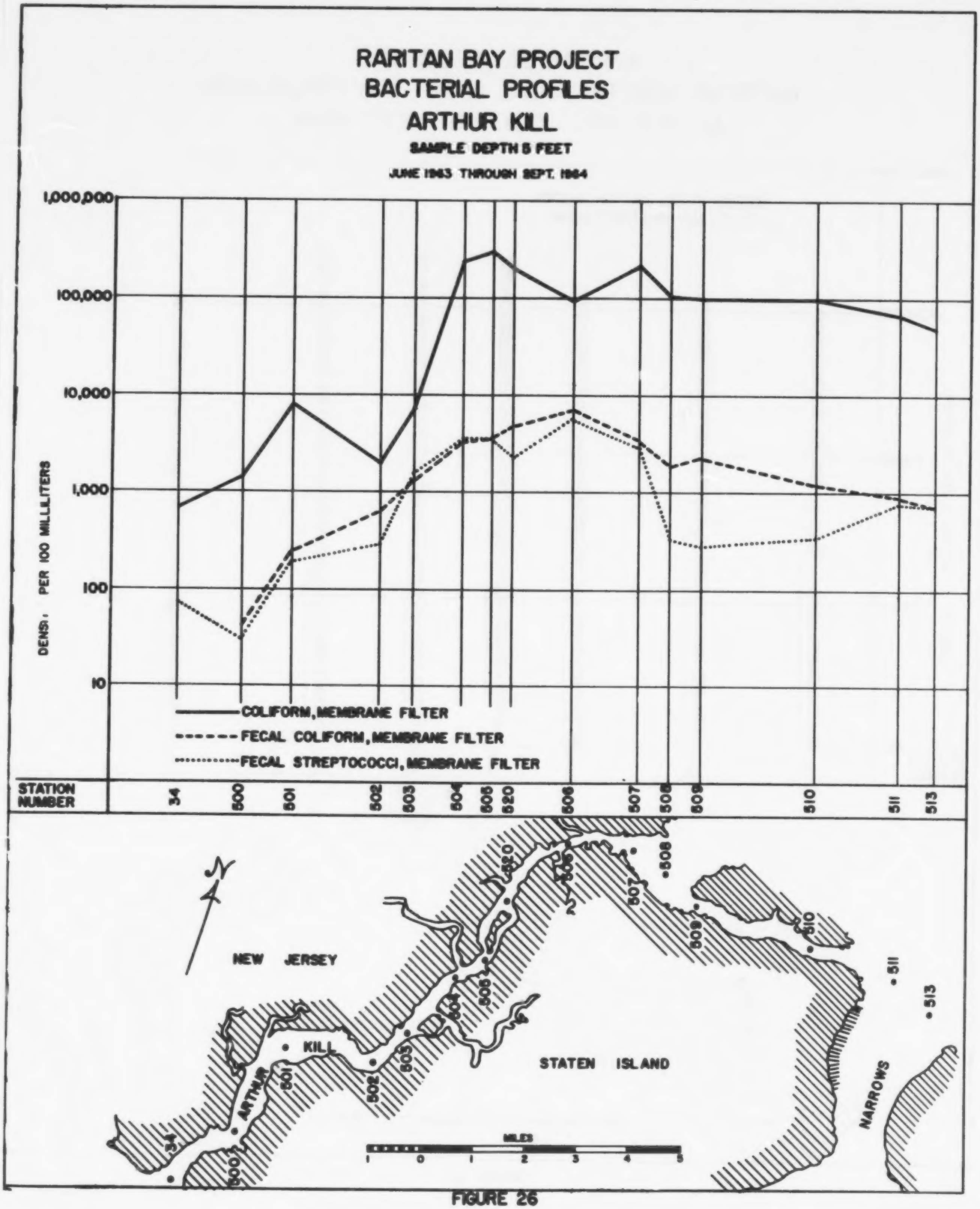
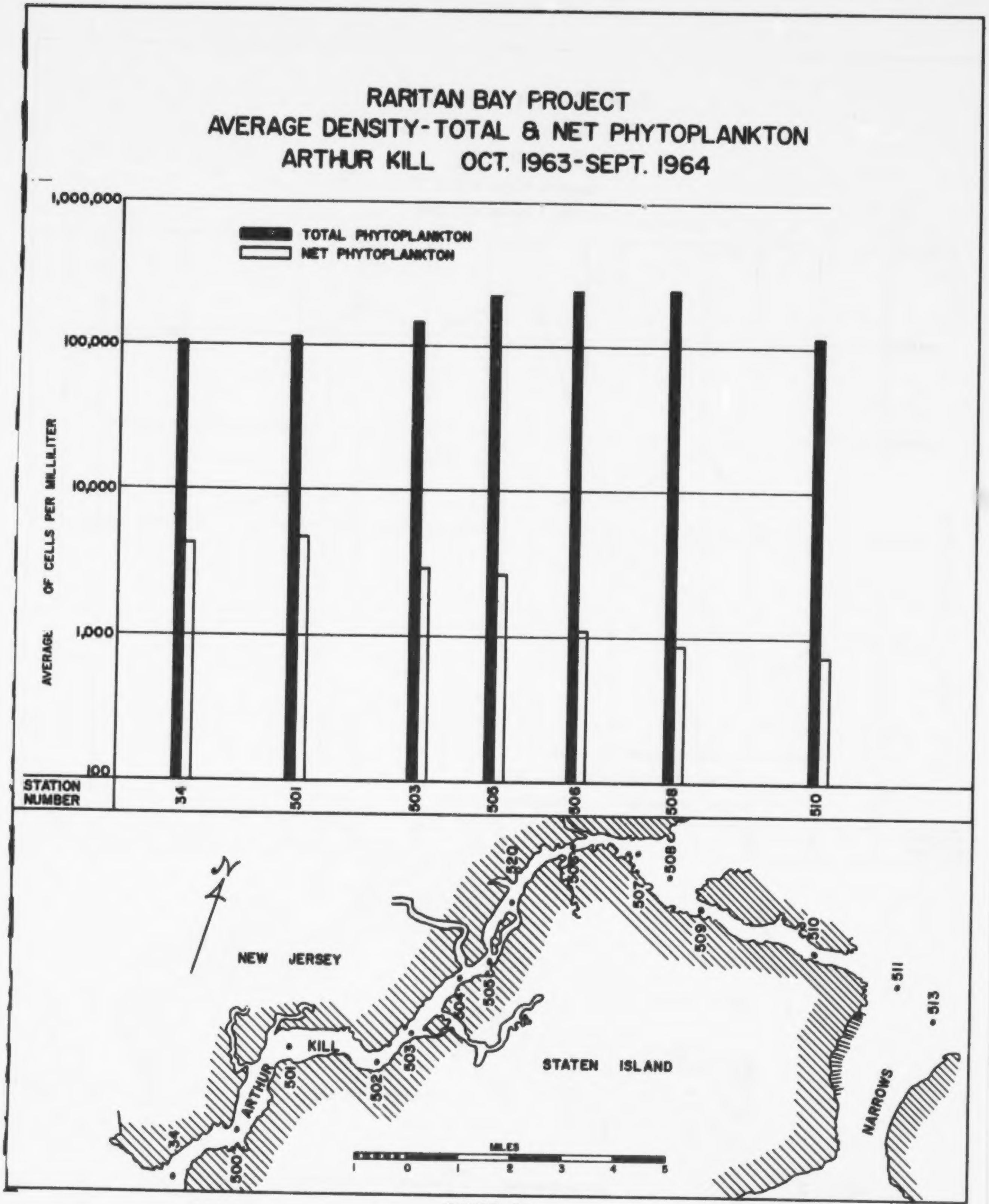
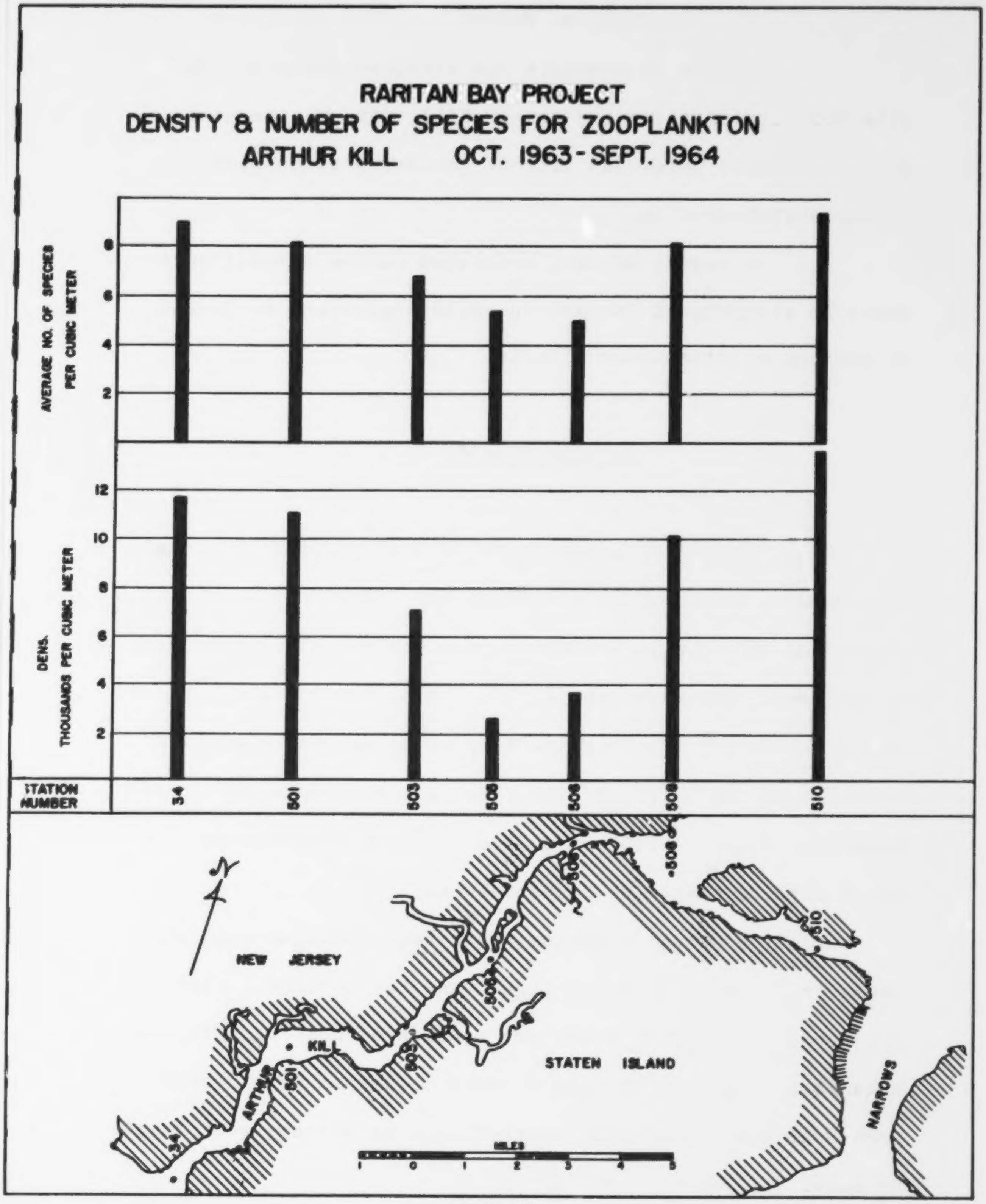

RARITAN BAY PROJECT
BACTERIAL PROFILES
ARTHUR KILL
SAMPLE DEPTH 5 FEET
JUNE 1963 THROUGH SEPT. 1964
1,000,000
100,000
10,000
1,000
100
10
DENS., PER 100 MILLILITERS
COLIFORM, MEMBRANE FILTER
FECAL COLIFORM, MEMBRANE FILTER
FECAL STREPTOCOCCI, MEMBRANE FILTER
STATION NUMBER
34
500
501
502
503
504
505
520
506
507
508
509
510
511
513
N
NEW JERSEY
STATEN ISLAND
ARTHUR
KILL
NARROWS
MILES
1
0
1
2
3
4
5

FIGURE 26



RARITAN BAY PROJECT
AVERAGE DENSITY-TOTAL & NET PHYTOPLANKTON
ARTHUR KILL OCT. 1963-SEPT. 1964

FIGURE 27



RARITAN BAY PROJECT
DENSITY & NUMBER OF SPECIES FOR ZOOPLANKTON
ARTHUR KILL OCT. 1963 - SEPT. 1964

FIGURE 28

GPO 956-592

Figure 29 presents the seasonal variation in selected nutrients for the Arthur Kill. At no time were nutrient levels below the minimum necessary to support phytoplankton growths.

A review of data collected during surveillance shows no significant changes in spatial patterns or levels of phosphate, nitrate or nitrite.

Benthic Studies

Table XIV presents results of studies of benthic organisms. Eleven miles of bottom from Station 501 to 509 was devoid of benthic animals. The three sampling runs made on October 1 and November 14, 1963, and June 15, 1964, showed little variation in either density of organisms or species found in the rest of the kill. Benthic organisms were never found in excess of 800 per square meter, nor were more than seven different species present at any station.

Dominant organisms were tube dwelling segmented worms principally Polydora lignii and the softshell clam, Mya arenaria, both of which are considered pollution tolerant organisms. Remains of dead benthic organisms were absent from Stations 502 to 508, suggesting that animals were unable to survive.

The only plant materials observed in the Arthur Kill between Stations 502 and 508 were the remains of land plants. Bottom material from all stations had an oily odor which was more intense between Stations 501 and 510. Bottom materials from Stations 508 through 510 also had the characteristic odor of hydrogen sulfide.

Bioassay

From June 24 to July 1, 1964, a field bioassay study was conducted. Three types of test organisms -- killfish, mud crab and shrimp -- were immersed in cages at four stations in the kill and at a station in Princess Bay, Staten Island, New York, which served as a control for the test. In addition to live caged animals, traps were placed at the same locations to permit observation of growth of the attached organisms. Results of this study are presented in Table XV.

At the control station in Princess Bay, 85 percent of the test organisms survived after seven days' exposure. At Stations 504 and 520 in the Arthur Kill-Kill Van Kull no organisms survived after two days. Survival at Station 507 was less than at Station 500. After two days no attached growth had formed on traps at Stations 504, 520 and

TABLE XIV

ARTHUR KILL BENTHOS SURVEY

October 1963

Sta.	Av. No's/M^2	Av. No. Species/M^2	Dominants	Odor	Observations
34	95	1.5	Polychaetes	Slight oil	Small shells (¼"-½"), wood
500	175	5.3	Polychaete	Slight oil	No shells, plant material
501	0		-	Oil	Few *Mya* SHELLS (¼"), plant material
502	3	0.3		Oil	No shells, plant material
503	0		-	Oil	No shells, little plant material
504	0		-	Oil	No shells, little plant material
505	0		-	Oil	Little plant material
520	0		-	Oil	Nothing
506	0		-	Oil	Little plant material
507	0		-	Oil	Nothing else
508	3	0.3	Polychaetes	Oil, H_2S	Nothing else
509	582	4.0	Polychaetes	Oil, H_2S	2 *Mya* shells (1"), little plant material
510	594	8.7	Polychaetes	Oil, H_2S	Plant material

TABLE XV

BIOLOGICAL SURVIVAL STUDY - ARTHUR KILL, JUNE 24-JULY 1, 1964

Station	Organisms In Time Est.	Date	Organisms Out	Number Survived	% Survival	Time Diff. Hrs.	Temp °C In & Out	Salinity %	D.O. mg/l	Observations
Control (Princess Bay)	1130	6-24	1400	7-1						Plant and animal growth on pilings where trap attached. After 1 week heavy plant and animal growth on trap.
	Fish 3			3						
	Crabs 7			5	84.6	170.5	20.5	24.70	10.15	
	Shrimp 10			3						
			(7 escaped)							
500	12N	6-24	1430	7-1						Plant and animal growth where attached. Heavy plant and animal growth on trap after 1 week.
	Fish 3			1						
	Crabs 6			5	75.0	170.5	21.6	23.96	5.30	
	Shrimp 1			3						
			(3 escaped)							
504	1315	6-24	1135	6-26						Pilings and trap free of growth.
	Fish 3			0						
	Crabs 6			0	0	46.7	23.4	21.41	0.4	
	Shrimp 6			0						
520	1400	6-24	1155	6-26						Pilings and trap free of growth
	Fish 0			0						
	Crabs 7			0	0	46.0	23.4	20.71	0.3	
	Shrimp 10									
507	1340	6-24	1235	6-26						Algal growth on pilings. Trap free of growth.
	Fish 3			0						
	Crabs 6			2	13.3	47.0	22.5	21.04	1.3	

SEASONAL NUTRIENT CYCLES-ARTHUR KILL
(AVERAGE FOR ALL BIOLOGY STATIONS)

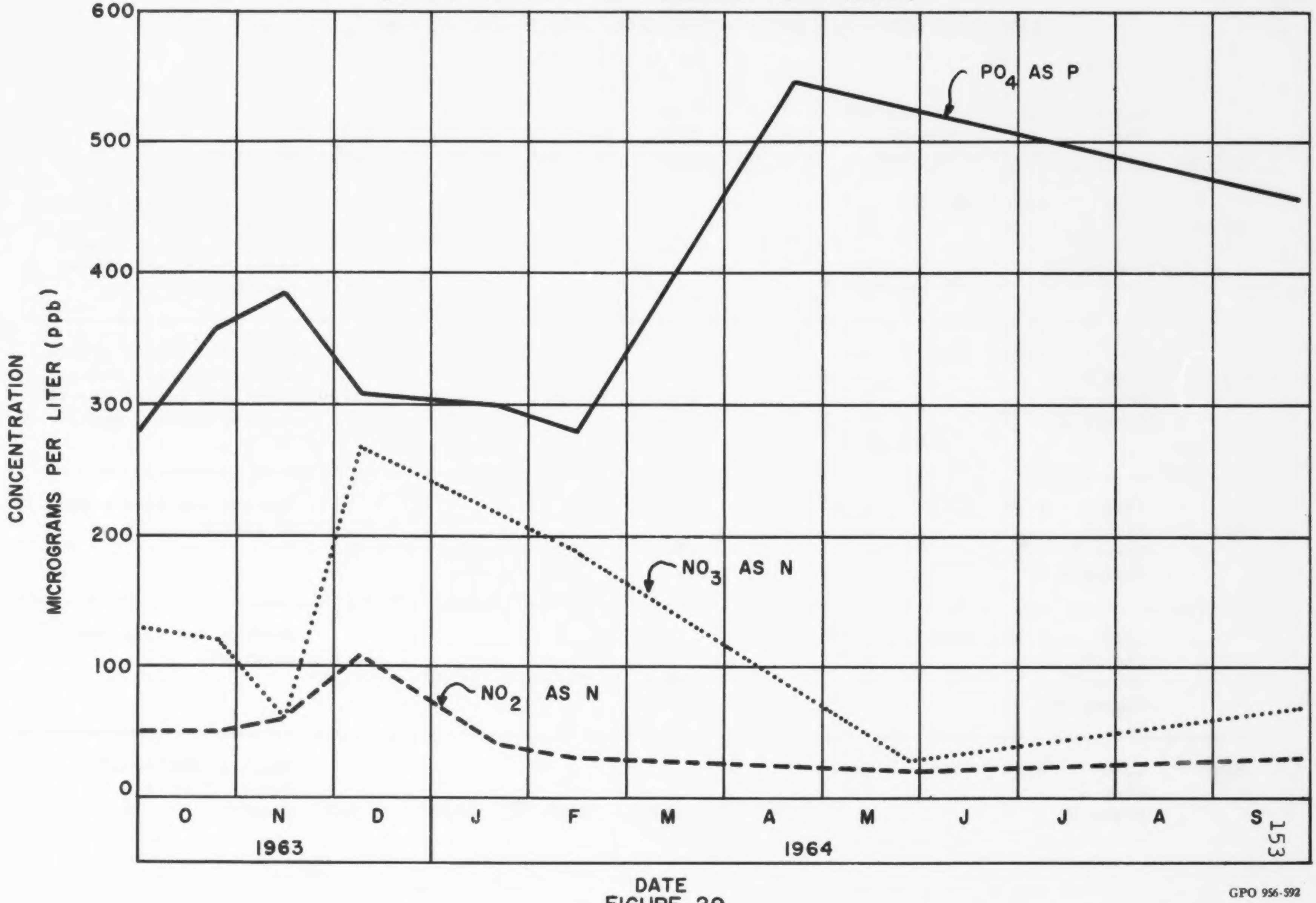


FIGURE 29

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507, while those at Station 500 and at the control station in Princess Bay had heavy growths. Those stations with the shortest survival times also had the lowest dissolved oxygen concentrations.

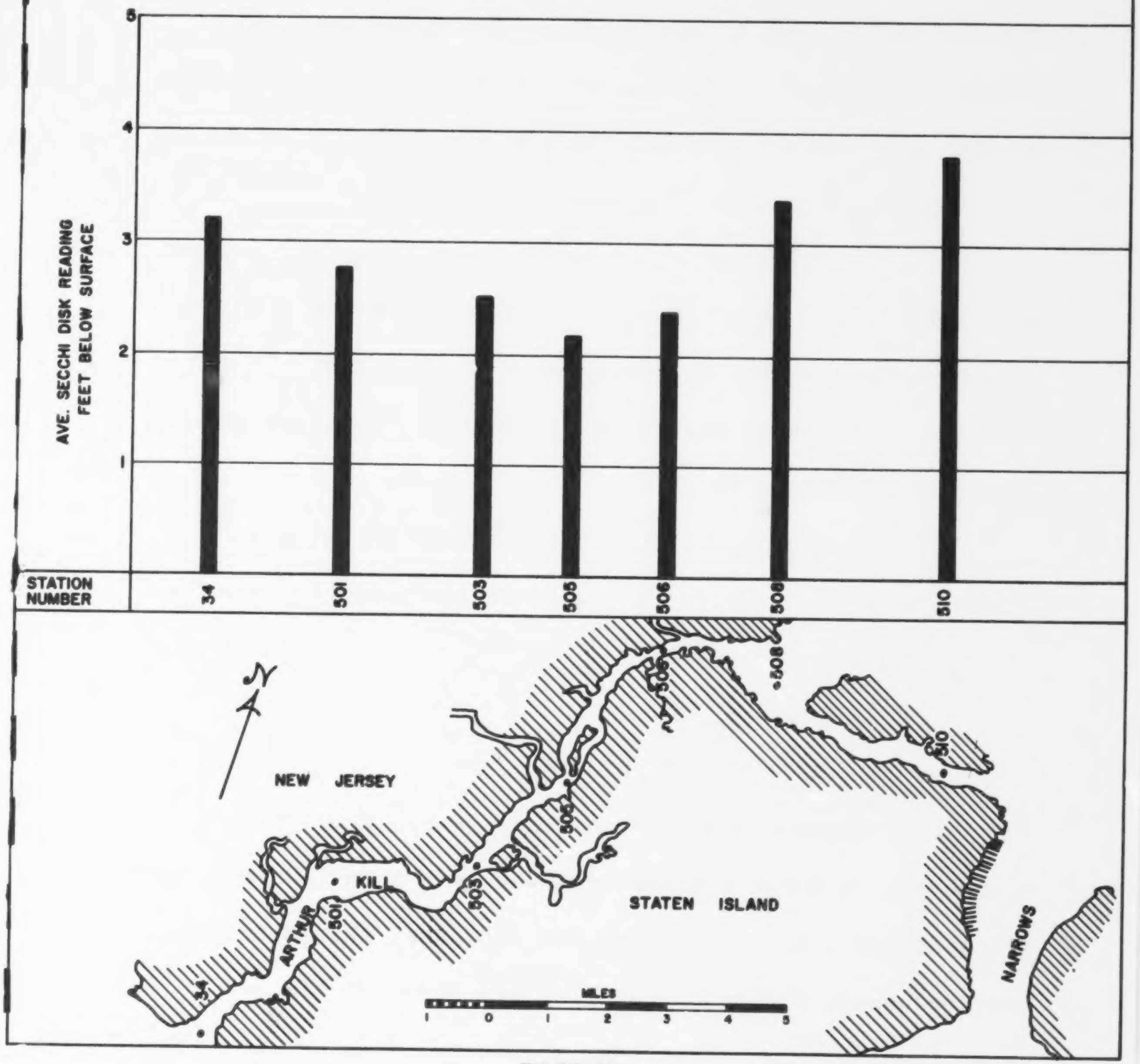
To evaluate possible toxicity of Arthur Kill water itself, rather than in conjunction with dissolved oxygen levels, test organisms were left for 48 hours in constantly aerated water taken from the various survival test stations. All organisms survived this experiment.

In other lab experiments, test organism survival was limited to several hours in Arthur Kill water when the oxygen content at the beginning of the experiment was 1.0 mg/l and no aeration was allowed. Further, survival was longer at 17°C than at 22°C.

Tests suggest that the observed toxicity to aquatic life in the kill is due at least in part to the low levels of dissolved oxygen.

Turbidity

Average Secchi disc readings are presented in Figure 30. Average transparency was less than four feet at all stations. Field observations indicated that detritus was frequently the major cause of the observed limited water transparency. This high turbidity restricts the depth



RARITAN BAY PROJECT
AVERAGE SECCHI DISK READINGS
ARTHUR KILL
OCT. 1963-SEPT. 1964
SAMPLE DEPTH 5 FEET

FIGURE 30

of light transmittance and results in limiting oxygen production by photosynthesis to a relatively shallow depth.

Raritan River

Presentation of analytical results are based upon data from three sources. Middlesex County Sewerage Authority operates a routine sampling program from Manville to Landing Lane Bridge -- river mile 12.8. In 1964, Hydroscience, Inc., Consulting Engineers, conducted a sampling program from mile 10.3 to its mouth. During the period August 5 through September 3, 1964, the Project installed and operated an electronic water quality monitor immediately upstream of the Fieldville Dam at mile 16.4. Discussion of results is based upon data provided by Middlesex County Sewerage Authority and Hydroscience, Inc., for sampling runs performed in July, August, September and October 1964. Results of Project monitoring at Fieldville Dam are presented separately.

Water Temperature

Variation in water temperature is shown in Figure 31. During July, August and September 1964 it ranged from 22 to 30°C. Considerable variation was found upstream of mile 10.3, New Brunswick; however, from this point to the mouth temperature remained relatively constant. Temperatures observed in October 1964 showed less variation with a range of 14 to 16°C over the entire reach of the river.

Chloride

Chloride data were available from mile 10.3 to the mouth at Raritan Bay. In July, August and October 1964 chlorides in this reach ranged from 1,000 mg/l at mile 10.3 to 14,000 mg/l at the mouth. Analyses performed in September 1964 showed a much higher chloride concentration at mile 10.3 with a value of 2,700 mg/l; however, streamflow during this survey was approximately 50 percent of that observed during the other three months.

BOD_5

Results of BOD determinations for the four runs in 1964 are presented in Figure 32. Maximum BOD was 40 mg/l at mile 18.9, which is immediately downstream of American Cyanamid Dam at mile 19.4. This same location was also the location of maximum BOD concentrations for all runs. Downstream from this point there was a gradual decline in BOD to values of 3 to 4 mg/l at the river mouth. Results for July and September were higher than those observed in August and October.

Dissolved Oxygen

Figure 33 presents dissolved oxygen concentrations observed in the four sampling runs for 1964. A similar pattern, high dissolved oxygen levels upstream of Cyanamid Dam, was observed for all samplings. Downstream from this point to the river mouth results indicate a decline in dissolved oxygen with minimum values in the New Brunswick area between mile point 8.0 and 12.0. A recovery to values of 2 to 6 mg/l occurs near the mouth. The run for September 1964 showed lowest values with the exception of mile 17.4. On this run, dissolved oxygen was less than 2 mg/l from mile 18.9 to 6.1, and was zero at mile 10.3.

Bacteriological Densities

Results of bacteriological sampling for MPN coliform from mile point 22.3 -- junction of the Millstone River, to mile point 12.8 are presented in Figure 34. At the confluence of the Millstone River MPN coliforms ranged from 200 to 1,100 per 100 ml. With the exception of October 1964, there was a rapid increase in coliforms from this point to the Cyanamid Dam, where counts in excess of 110,000 per 100 ml were found. Downstream from this point, coliform counts remained high, in no case falling below 1,100 per 100 ml. In September 1964 coliform counts downstream of the Cyanamid Dam were in the range of 10,000 to 100,000 per 100 ml.

pH

In July and September 1964 there was a significant decrease in pH between the Millstone River and Cyanamid Dam. In July, pH declined from 8.2 to 7.3 and in September dropped from 8.5 to 7.4. This sudden change was not observed in August and October.

Color

During all four runs color at the confluence with the Millstone ranged from 15 to 30 units. Downstream from this point to the Cyanamid Dam, mile point 18.9, there was a significant increase in color. At Station 18.9 color ranged from 100 to 250 units.

Water Quality Monitoring

During the period August 5 to September 3, 1964, an ORSANCO type electronic water quality monitor was in operation in the pool immediately upstream of the Fieldville Dam -- mile point 16.4. The monitor collected continuous data for dissolved oxygen, water temperature, turbidity and oxidation reduction potential. During this same period eight-hour composite samples were collected on several occasions. Results of these analyses, together with average monitor readings for the periods indicated are presented in Table XVI. During this period of time BOD and phenol values more than doubled with maximum values of 42 mg/l and 162 ppb respectively. Dissolved oxygen readings declined to zero and oxidation reduction potential became negative. Septicity developed and extensive gas production was observed by Project staff.

Water quality conditions at the mouth of the Raritan River have been analyzed by an ORSANCO robot monitor, located at the Victory Bridge, Perth Amboy, New Jersey, since 1962. Monitoring results during 1964 confirmed upstream analyses described previously.

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Maximum recorded dissolved oxygen at Perth Amboy was 13 mg/l, or 125 percent of saturation in April 1964. During the late summer and early fall of 1964 dissolved oxygen levels were reduced with a minimum observed value of 0.3 mg/l on September 16th. During this same period of time oxidation reduction potential was observed to have negative values for intermittent periods of two to three consecutive days, as compared to the normal range observed of up to 400 millivolts.

TABLE XVI

RARITAN RIVER WATER QUALITY DATA
FIELDVILLE DAM

Date	BOD mg/l	COD mg/l	Org N mg/l	Phenol ppb	DO* mg/l	Min ORP* mv	Temp.*
8/5/64	8	53	10.7	34	-	-	-
8/6/64	8	56	10.6	32	2.9	435	74
8/12/64	13	69	12.9	45	2.4	273	74
8/18/64	16	87	20.6	69	0.21	0	72
8/19/64	11	87	19.9	78	2.6	Neg.	74
8/28/64	18	111	19.7	50	0.09	Neg.	75
8/29/64	18	119	21.6	62	0.10	Neg.	75
9/2/64	-	176	34.3		0.08	Neg.	74
9/3/64	-	284	34.0		0.09	Neg.	74
9/8/64	36	247	37	125	0.15	-	72
9/9/64	42	234	36	162	0.15	-	73
9/10/64	37	196	37	120	0.14	-	73
9/11/64	37	175	30	121	0.12	-	73

*Data from ORSANCO robot monitor.

All other data based on average of three 8-hour composite samples.

WATER TEMP., RARITAN RIVER

JULY-OCT., 1964

DEPTH 2 FEET

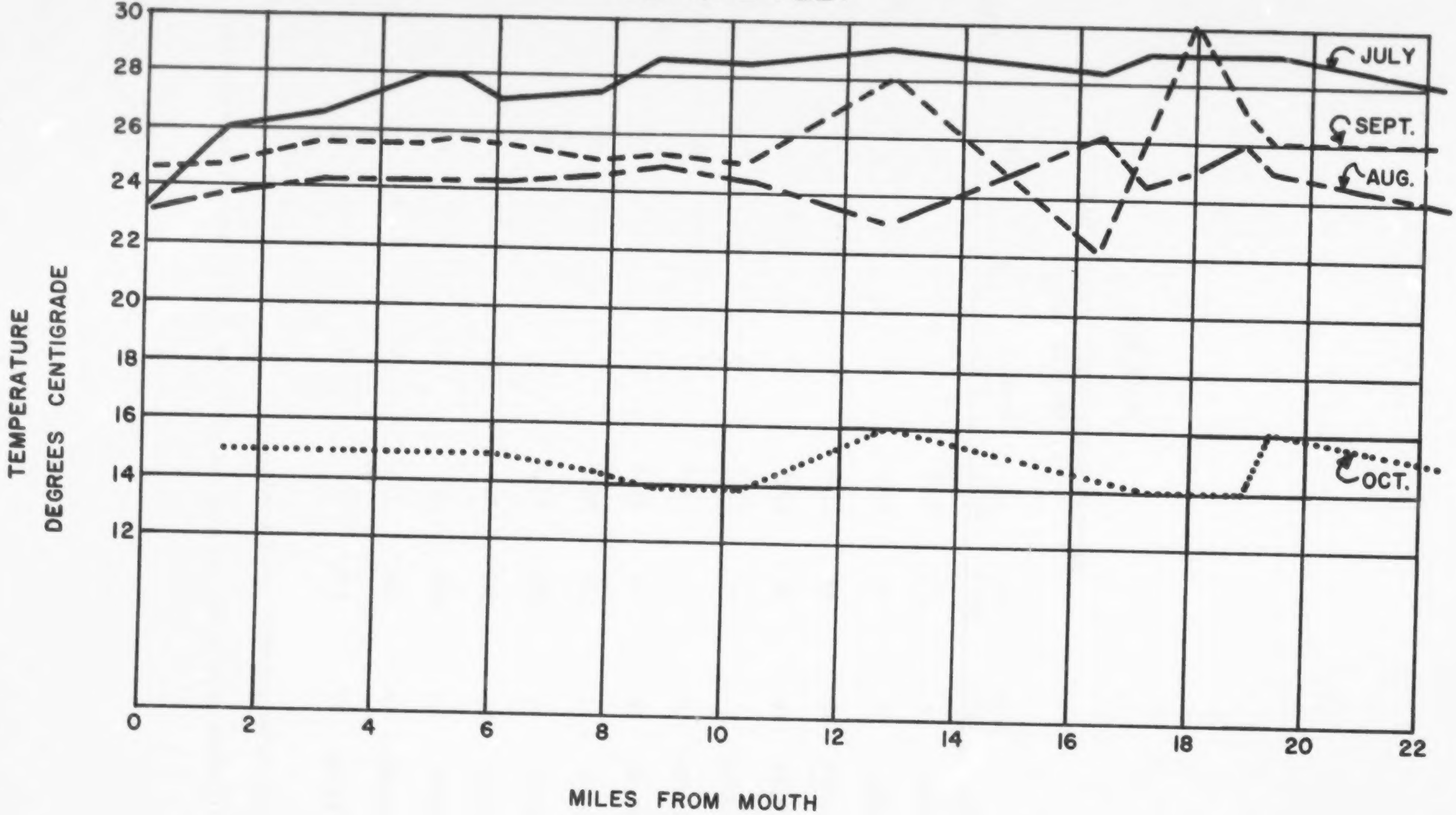

FIGURE 31

BIOCHEMICAL OXYGEN DEMAND
RARITAN RIVER
JULY-OCT., 1964

DEPTH 2 FEET

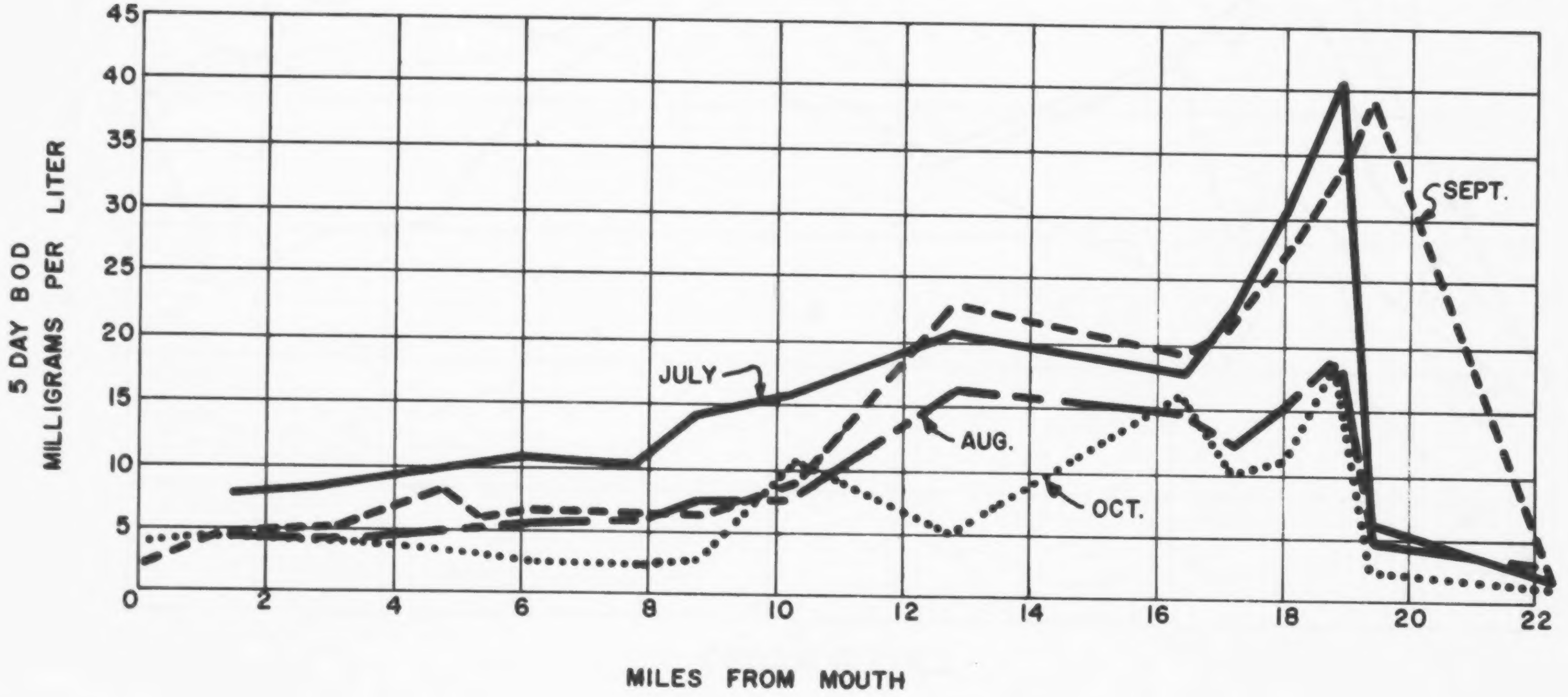

FIGURE 32

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DISSOLVED OXYGEN
RARITAN RIVER
JULY-OCT., 1964
DEPTH 2 FEET

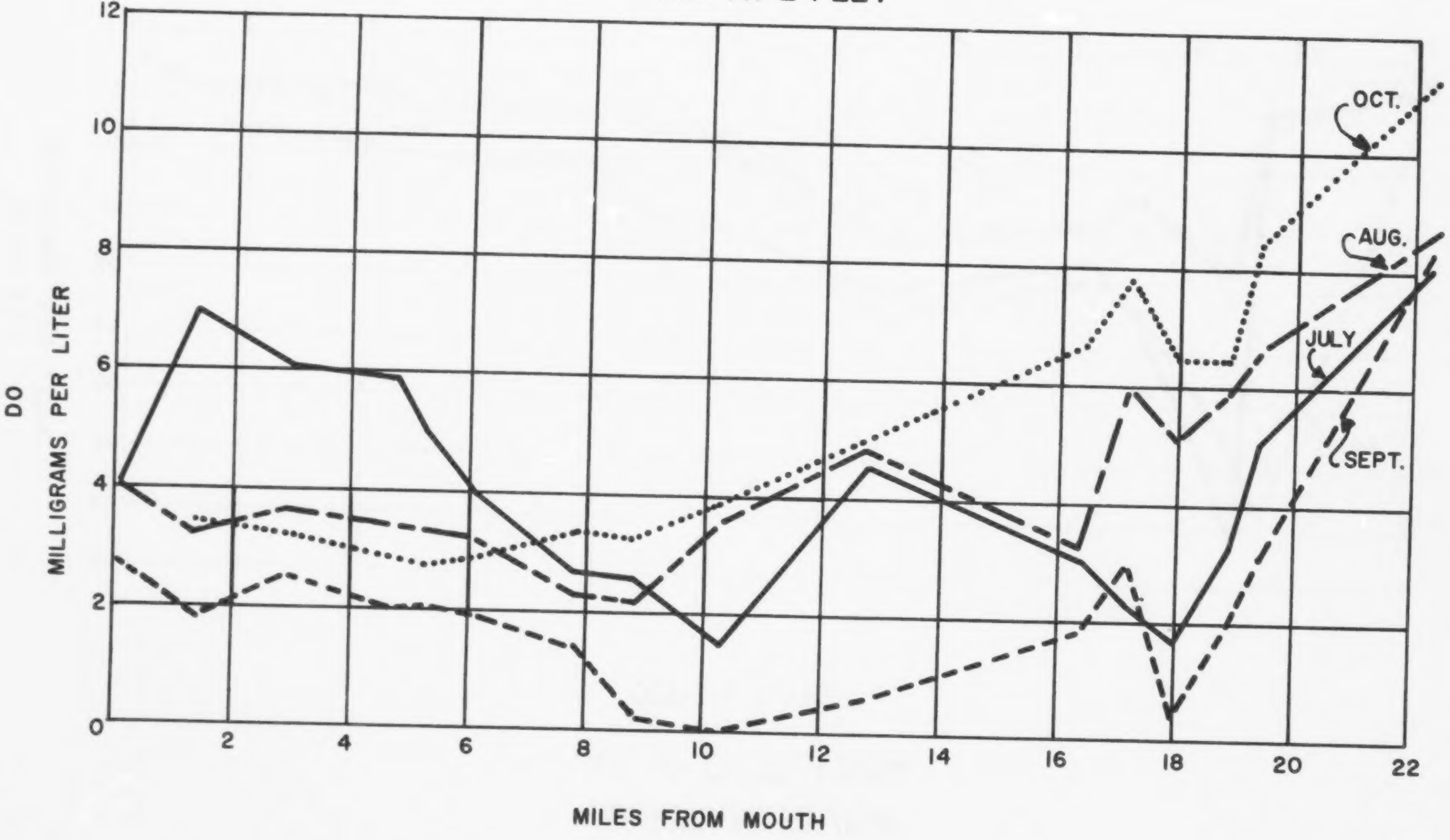

FIGURE 33

MPN COLIFORM, RARITAN RIVER

JULY-OCT., 1964

DEPTH 2 FEET

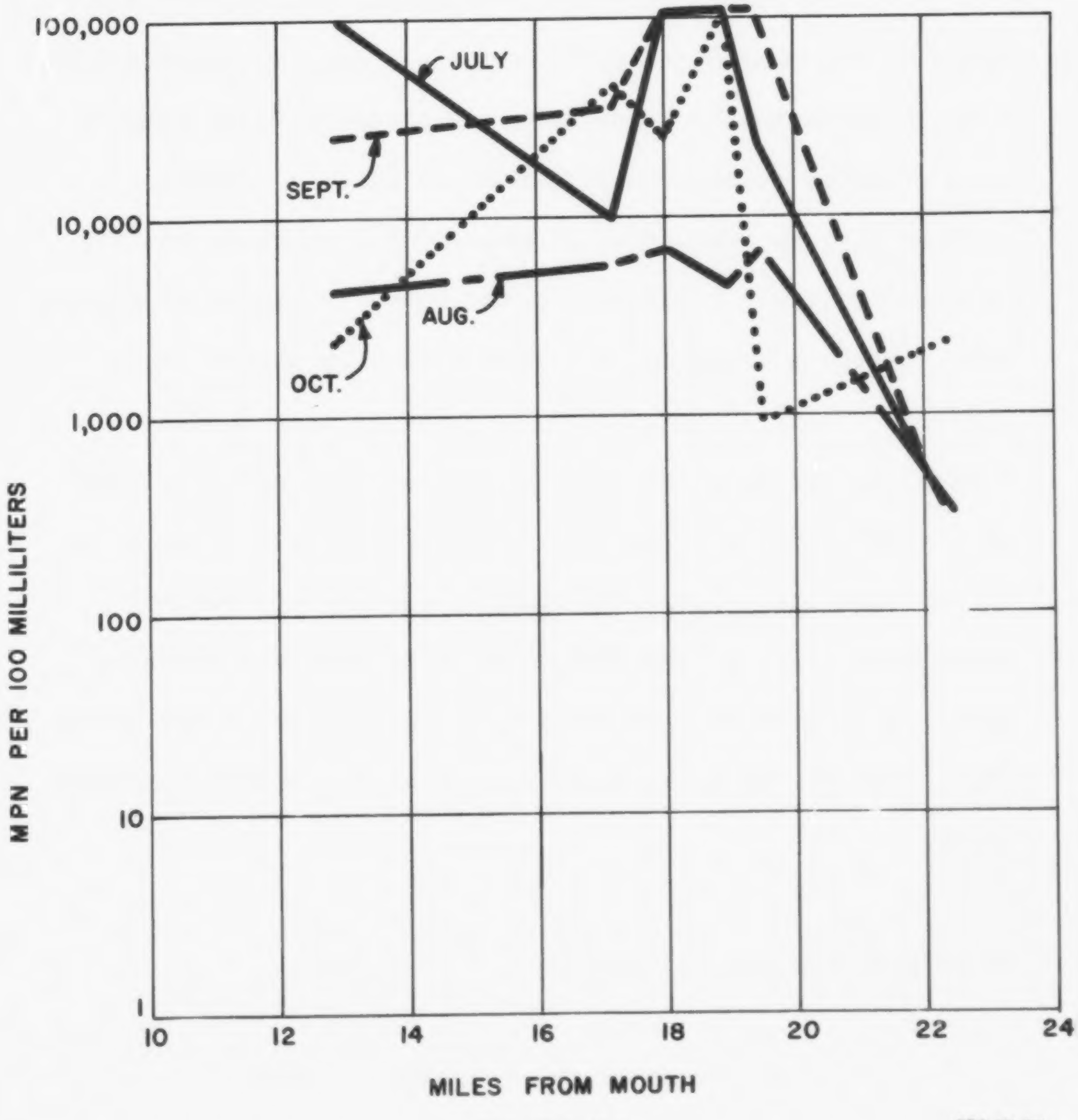

FIGURE 34

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SPECIAL STUDIES

A number of special investigations were undertaken by the Project to provide further data on water pollution problems in the study area. Included were an examination of water movement and dispersion patterns within Raritan Bay; an evaluation of the effects on water quality of combined sewer overflows; mathematical analyses to explain the variations found in the chemical and bacteriological analysis of bay water samples; a study of the relationship between chlorination of wastewater treatment plant effluents and bacteriological densities in Raritan Bay; determination of the bacteriological and chemical quality of shellfish taken from the bay; and isolation of certain pathogenic bacteria from study area waters, sewage effluents and shellfish. Results of these special investigations are presented below.

Water Movement and Dispersion

Examination of the geographical structure of the study area suggests the hydraulic complexity of the system, due to interconnections between the bodies of water as well as other waters external to Raritan Bay and Arthur Kill. Any satisfactory pollution control program developed for Raritan Bay and Arthur Kill must be based on knowledge of the movement of waters between these various bodies so as to recognize probable paths of flow of pollutional materials. Accordingly, the Project conducted investigations of water movement by tracer dye studies, geological investigations, and by reviewing available hydraulic model data. Dye studies provided information on water movement and dispersion characteristics under conditions actually observed at the time of each dye release. The geological survey of Raritan Bay was conducted to obtain information on long-term water movement and distribution of sediment throughout the bay. Previously reported studies by the U. S. Army Corps of Engineers on the Vicksburg model of New York Harbor were reviewed to obtain further information on the interrelationship between the various bodies of water involved in the Raritan Bay Project study area.

Dye release studies were made in the Raritan River, Arthur Kill, westerly portion of Raritan Bay and in Upper Bay to observe the interrelationship of these waters. Rhodamine B dye, used in all studies conducted by the Project, was added to the water as an instantaneous release. In all studies, except upper Raritan River, resulting movement of dye was monitored visually and by the use of Turner florometers for as long as deemed advisable. During the monitoring phase, boats equipped with fluorometers and continuously recording Rustrak meters cruised the dye mass to determine its movement, location of the limits, and the peak concentrations. Monitoring boats proceeded on a predetermined course -- established between known navigational aids -- at a fixed rate of speed. In addition to recording dye concentration, records were also maintained on time and boat course so as to permit proper correlation between an observed dye concentration and the exact location and time of such reading.

The Raritan River dye study of April 1964 was limited to a simple measurement of time between release and the appearance of dye at a downstream location.

On August 15, 1962, dye was released at high water slack in the western end of Raritan Bay near the Ward Point secondary channel. Dispersion of the dye was monitored over a period of four days. Dye moved as a fairly well defined mass, with the outer limits readily discernible during the first day. During the second and third days, dye became progressively more diffused and was distributed laterally, longitudinally and vertically throughout the inner bay. At the end of this three-day period, dye was still detectable at the following locations:

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(1) Raritan River at Victory Bridge;

(2) Arthur Kill at Tufts Point;

(3) Raritan Bay at Seguine Point, Staten Island, New York;

(4) Raritan Bay off Keyport, New Jersey.

The outline of the dye mass five tidal cycles after release is shown in Figure 35. After the five tidal cycles peaking was still discernible just east of the original dye release area. The net movement of the dye mass had been approximately 1/2 mile seaward over the five tidal cycles, suggesting a net seaward movement of the dye at a rate of approximately one-tenth mile per tidal cycle.

On October 17, 1962, at low water slack, dye was released in the Arthur Kill just below Outerbridge Crossing. Release was timed to enable observation of the seaward movement of the dye under the most adverse conditions of current movement. Under low water slack conditions dye must first transit upstream with the incoming current; then reverse at the turn of tide and run downstream out from the kill. Monitoring was carried out for four days. Dye dispersed throughout the entire kill area as far north as Goethals Bridge. At the end of four days, dye was dispersed uniformly throughout the entire western end of Raritan Bay, in the same areas and in approximately the same concentrations that were found after the August 1962 dye release in the bay. The peak of the dye concentration after four days was located in the deep water anchorage southeast of Perth Amboy, New Jersey. The net seaward movement of the dye mass was approximately nine miles in a period of eight tidal cycles, or approximately one mile per tidal cycle. This study indicated that material introduced into the Arthur Kill near the Outerbridge Crossing at low slack tide would:

(1) Affect a stretch of 10,000 yards to the north in six hours;

(2) affect the western end of Raritan Bay within 12 hours;

(3) affect the entire Arthur Kill within 30 hours, and Newark Bay within 54 hours;

(4) affect Raritan Bay on a line from Seguine Point, Staten Island, New York, to Keyport, New Jersey, within 48 hours.

Diffusion coefficients in the Arthur Kill were found to be 0.1 to 2.7 square miles per tidal cycle. Results of this dye study are shown in Figure 36.

On April 14, 1964, dye was released at high water slack at New Brunswick, New Jersey, on the Raritan River. Dye was monitored for five days throughout the 13-mile navigable reach of the river, the five-mile navigable reach

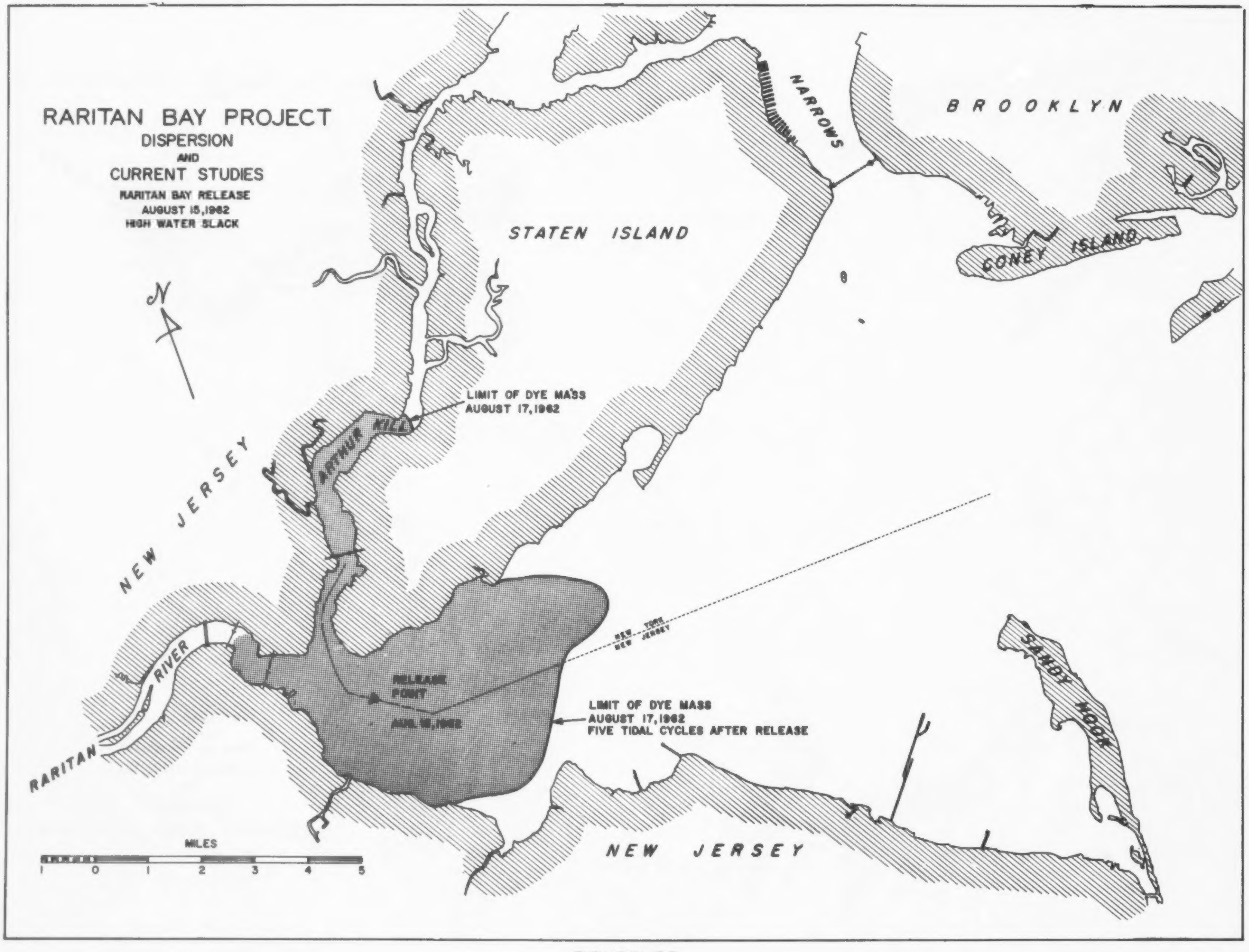
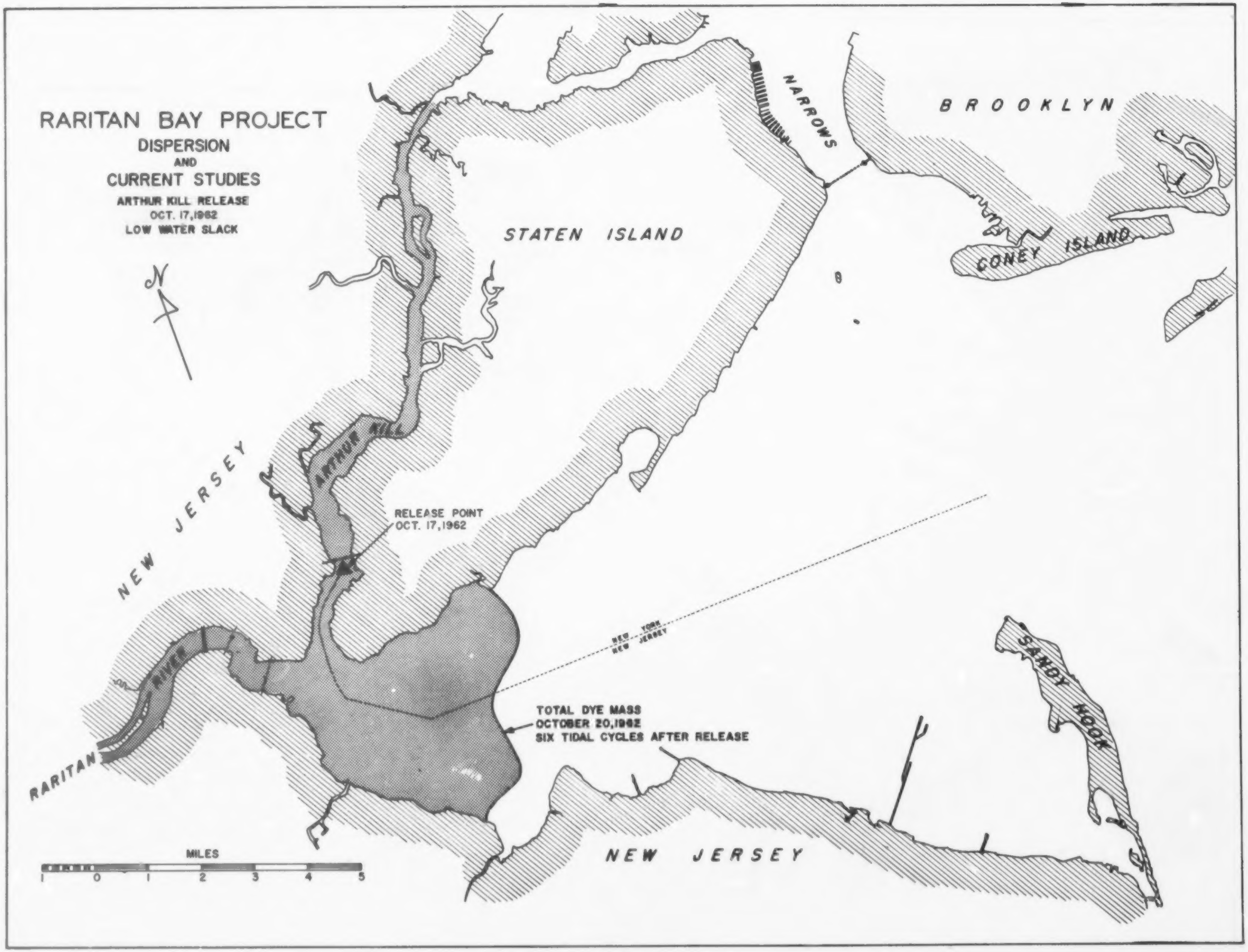

RARITAN BAY PROJECT
DISPERSION
AND
CURRENT STUDIES
RARITAN BAY RELEASE
AUGUST 15,1962
HIGH WATER SLACK
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
LIMIT OF DYE MASS
AUGUST 17,1962
ARTHUR KILL
NEW JERSEY
NEW YORK
NEW JERSEY
RELEASE POINT
AUG. 15, 1962
LIMIT OF DYE MASS
AUGUST 17,1962
FIVE TIDAL CYCLES AFTER RELEASE
SANDY HOOK
RARITAN RIVER
MILES
1
0
1
2
3
4
5
NEW JERSEY

FIGURE 35



RARITAN BAY PROJECT
DISPERSION
AND
CURRENT STUDIES
ARTHUR KILL RELEASE
OCT. 17,1962
LOW WATER SLACK

N
BROOKLYN
NARROWS
CONEY ISLAND
STATEN ISLAND
NEW JERSEY
ARTHUR KILL
RELEASE POINT
OCT. 17,1962
NEW YORK
NEW JERSEY
TOTAL DYE MASS
OCTOBER 20,1962
SIX TIDAL CYCLES AFTER RELEASE
SANDY HOOK
RARITAN
RIVER
NEW JERSEY
MILES
1
0
1
2
3
4
5

FIGURE 36

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of South River and Washington Canal, and the western end of Raritan Bay. Results of this study showed that:

(1) Material introduced at New Brunswick affects the river downstream to the Washington Canal entrance within six hours;

(2) such material can affect the western portion of Raritan Bay within 18 hours;

(3) on entering Raritan Bay the dye followed two paths, one along the navigation channel to the north and east, the second along the New Jersey shore line to the south;

(4) such a release had little effect upon the Arthur Kill.

On June 30, 1964, a dye release was made at Fieldville Dam on the Raritan River, five miles upstream of New Brunswick, New Jersey. This study indicated a time of passage from the dam to New Brunswick of at least 14 hours.

On September 16, 1964, dye -- 1,000 pounds -- was released at high water slack over the Passaic Valley Sewage Treatment Plant outfall near Robbins Reef in Upper Bay. This point is located on the western edge of the bay channel about 700 yards north of the Kill Van Kull. This dye release showed the following results:

(1) Material introduced in the northwest sector of the Upper Bay affects a broad

area of Lower Bay, and is found on the Staten Island shore from Midland Beach to the Narrows within six hours of release;

(2) within 32 hours of release such material affects a large area of Raritan Bay, and is found on the Staten Island shore from the Narrows to Great Kills, as well as on the Coney Island shore of Brooklyn;

(3) on an ebb current there was little lateral mixing across the Narrows, but lateral mixing does occur on the first flood current following release;

(4) material moving from the release point on the first ebb passes along the western edge of the channel and the Staten Island shore before passing through the Narrows.

The limits of the dye mass at various stages of time following release are shown in Figure 37.

A geological investigation of Raritan Bay was made to obtain information on long-term water movement and sediment distribution. Details on this study and its results are contained in the Appendices to this report. In summary, the investigation found, based upon the sediment distribution within the bay, that:

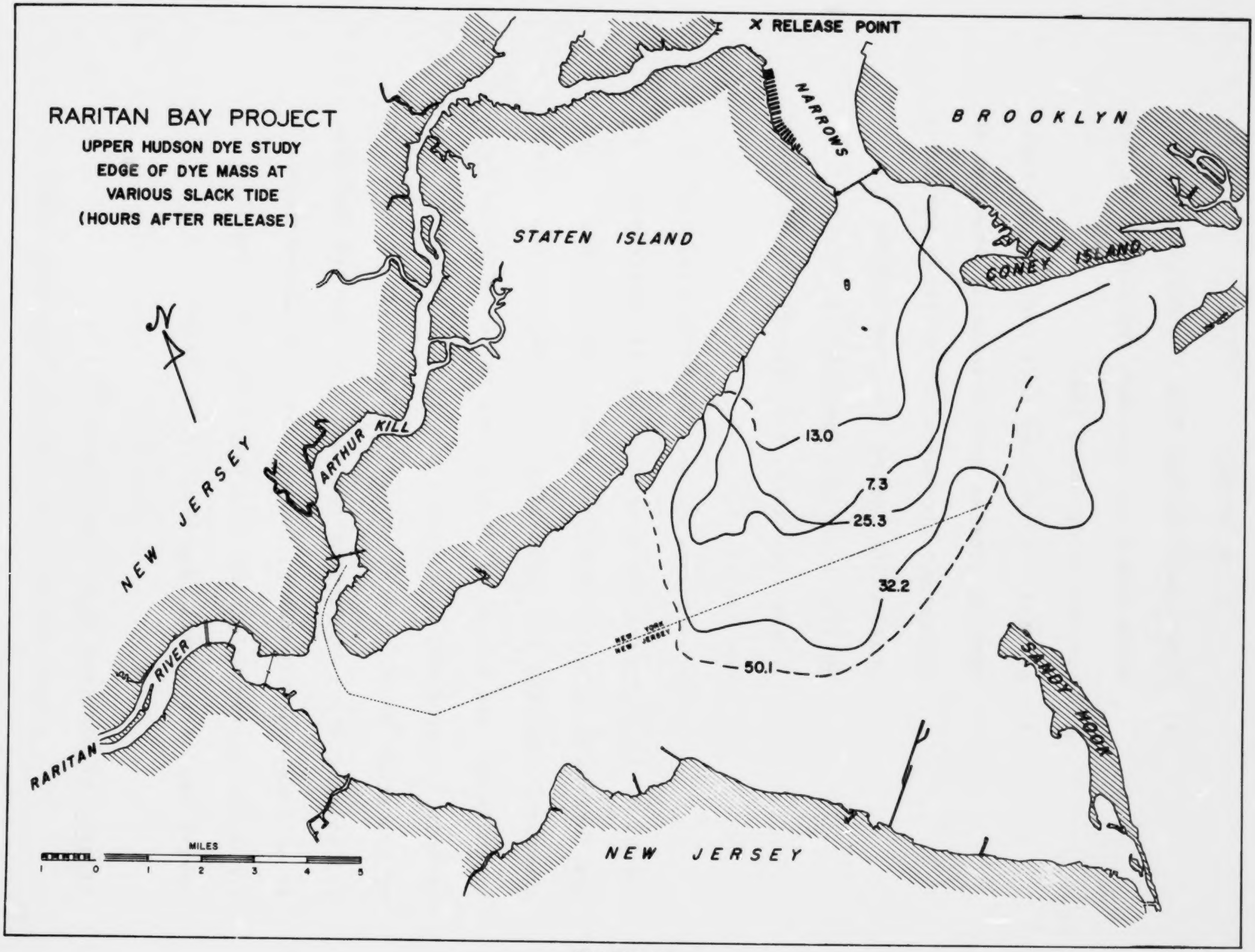
RARITAN BAY PROJECT
UPPER HUDSON DYE STUDY
EDGE OF DYE MASS AT
VARIOUS SLACK TIDE
(HOURS AFTER RELEASE)
X RELEASE POINT
NARROWS
BROOKLYN
CONEY ISLAND
STATEN ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW YORK
NEW JERSEY
13.0
7.3
25.3
32.2
50.1
N
MILES
1 0 1 2 3 4 5

FIGURE 37

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(1) Fresh water inflow from the Raritan River moves along the southern section of the bay towards Sandy Hook; and

(2) particles introduced into the bay at widely varying locales were eventually transported throughout the bay with the finer particles gravitating toward the area bounded by Seguine Point and Great Kills, Staten Island, New York, and Keyport and Keansburg, New Jersey.

Project studies, as well as those performed by the U. S. Army Corps of Engineers on the Vicksburg model of New York Harbor, which have been previously reported by other agencies, indicate the complexity of the Raritan Bay system. Essentially, the waters of Raritan Bay may be affected by materials discharged into waters outside the immediate limits of the study area. Hence, any effective control program for pollution control in Raritan Bay must consider the bay not as an independent estuary, but as part of a larger interconnected system which includes Upper Bay, Kill Van Kull, Newark Bay, Arthur Kill and the Raritan River.

Effects of Combined Sewer Overflows

Within the metropolitan New York area there are a number of combined sewer systems. During normal dry weather periods wastes conveyed by these sewers receive treatment if facilities exist. During periods of heavy rainfall, when these sewers must carry both wastes and stormwater, bypassing of treatment facilities via regulating chambers or overflows is necessary. The Project attempted to evaluate the effects on bacteriological water quality resulting from the overflow of such discharges during periods of heavy rainfall. Two systems, that of Perth Amboy, New Jersey, and Brooklyn, New York, were selected for analysis. Sampling stations 33, 34 and 62, at the confluence of the Raritan River and Arthur Kill, were selected as being indicative of water quality in the vicinity of the Perth Amboy combined sewer system, and readily affected by overflows from that system. Station 102 in the Narrows was similarly selected as being indicative of the effects of discharge by stormwater overflows from the Brooklyn area. Bacteriological data collected by the Project for the period July 1962 through September 1963 were utilized for Perth Amboy Stations 33 and 34, and data from January 1963 through September 1963 were used for the Narrows Stations 102 and 62. Rainfall information for the study period was obtained from published records of the U. S. Weather Bureau. The station at Rahway, New Jersey, was selected as the nearest location to Perth Amboy and the station at Avenue V, Brooklyn, New York, was used for the Narrows. Several analyses described below were made of these data to determine if any correlation could be found between rainfall and high bacterial densities in the receiving waters.

Graphs were prepared with total coliform and fecal streptococcus counts, as well as daily rainfall plotted on the ordinate and date on the abscissa. The resulting display of variations in bacteriological density and rainfall for each station was examined visually; however, there was no apparent correlation. Coliform and fecal streptococcus data for each station were next separated into those data collected at ebb tide and those collected at flood. Two graphs were then plotted for each station, as above, using only ebb tide data for one and flood data for the second. Again, visual examination of these graphs showed no apparent correlation.

Bacteriological data were then separated into four groups: Collected within 24 hours of rainfall; within 48 hours of rainfall; within 72 hours of rainfall; and that collected with no rainfall for 72 hours prior to collection. Scatter diagrams were made with the classification by above groups as the independent variable and the bacteriological data as the dependent variable. No relationship was apparent with this approach.

All bacteriological data which had been collected with rainfall appearing up to three days prior to collection were then listed. Individual graphs were made with hourly rainfall and bacteriological counts as the ordinate and time as the abscissa. Areas under the hourly rainfall graph were then calculated for periods of 24, 48 and 72 hours. Secondary graphs were then made with the area from the rainfall curve as the independent variable and bacterial counts densities as the dependent variable. Again no relationship was found.

The techniques used suggest no apparent correlation between rainfall and high bacteria counts; however, it cannot be concluded that stormwater overflows have no effect on water quality in Raritan Bay. The data available were not specifically collected for such analysis; more important, the raw sewage discharges into the areas of the bay considered would undoubtedly mask any effects by stormwater overflows. Once the discharge of raw sewage is discontinued, and all treated wastes discharges receive adequate chlorination, such stormwater overflows may constitute a serious pollution problem. However, at present the problem of stormwater overflows cannot be defined, as any effects are so obscured by poor water quality attributable to other factors.

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Mathematical Analysis of Sampling Variation

In order to validate the sampling program adopted by the Project, provide an estimate of the most representative parameter values, and serve as a guide for future sampling programs, analytical data were subjected to a time series analysis. The analysis served to develop predictable time dependent components of observed variations in parameter values.

To determine cyclical components of a time series available data should be distributed in time over the periods to be determined. Three sampling procedures used by the Project yielded data distributions suitable for time series analysis. These were:

(1) Simultaneous sampling of bay, shoreline and wastewater treatment plant effluent stations on a weekly interval over a one-year period;

(2) sampling of selected bay stations on an hourly interval over a 24-hour period; and

(3) continuous automatic sampling on a 30-minute interval by an electronic monitor located at Victory Bridge at the mouth of the Raritan River.

Weekly samples were taken at a grid of locations in the bay, along the shoreline, and at eight sewage treatment plant effluents during the 56-week period from August 1962 through September 1963. Initially, in the bay stations, only those numbered 1 through 34 were sampled. Effective February 13, 1963, additional stations were established and some of the original stations were discontinued to permit a better description of the pollution gradients. Only 31 of the 50 weekly stations were sampled over a full year and used for this analysis because of this change. Parameters selected for the time series were air temperature, sample temperature, dissolved oxygen, chloride, MF fecal streptococcus, MPN confirmed coliform, and MPN fecal coliform. Stations were sampled at nearly the same time each week, since a preset course and consistent starting time were followed. On occasion, due to inclement weather, it was necessary to delay the sampling one day or to completely omit a week; however, the maximum number of consecutive weeks of missing data for any parameter was three.

Samples taken on the same day of the week and hour of the day for one year would be uniformly distributed over an annual cycle. However, the 12.42-hour tidal period is such that there would be a 0.526 cycle interval between individual weeks and a 0.053 cycle interval every two weeks.

Therefore, after one year of sampling while analytical values would be distributed over the entire tidal cycle, the 0.526 weekly and 0.053 biweekly cycle intervals would generate respectively what would appear to be a two-week and 19-week period. Any 24-hour or seven-day cyclic variation present would not be measured by this sampling procedure, but would bias the mean by as much as ± the amplitude of the variation.

A least squares regression analysis was performed on the weekly interval data so as to fit a base value, linear trend, and annual and tidal cycles. This analysis has the advantage over other procedures of using actual sampling times, which need not be equally spaced, and makes possible estimates of high frequency components. The final form of the equation developed for this regression is as follows:

$\text{Parameter} + M+At+B \cos (w_1 t-\phi_1) + C \cos (w_2 t-\phi_2)$ where

M = Base value

A = Slope of linear trend

B = Amplitude of annual component

C = Amp. of tidal comp.

ϕ_1 = Lag of annual comp.

ϕ_2 = Lag of tidal comp.

t = Time from time zero*

w = Angular frequency with time = $\frac{2TT}{\text{period}}$

*Time zero was established as low water slack on August 6, 1962. The four components of this equation, i.e., base value, trend, tidal and annual, cannot describe completely all of the parameter variation. The remaining variation, referred to as the unexplained component, was defined as the standard error of the estimate and calculated as:

$$U = \sqrt{\frac{\sum (P_o - P_c)^2}{6}}$$

where P_o = observed value

P_c = calculated value

U = unexplained term

The base value obtained from the regression is a good estimate of the true parameter mean value. It is not biased by the sampling distribution over the periods of variation such as tidal or seasonal cycles, as the commonly computed mean could be. The base value may be biased, however, by a non-cyclic trend or by sampling at same point on a cycle as was done for the 24-hour and seven-day cycles.

The trend coefficient is for a purely linear term. In reality it may be part of either a cyclic period longer than one year or a non-linear, non-cyclic term. Since it is impossible to determine which of these is the case with the information available, the trend should be viewed only as a means of estimating the magnitude of variations measured in years, and no significance should be given to the sign.

The unexplained variation term contains all variations caused by:

(1) Non-linearity of the trend;

(2) cyclic terms, other than annual or tidal;

(3) random causes (non-cyclic), such as analytical error, slug releases and unusual weather.

Figure 38 presents graphically dissolved oxygen results of the regression for Station 34S. During any given day the DO would be expected to vary within the limits shown by the two solid line curves and average the value on the dashed line curve. Within this day it is possible to estimate the DO within ± 1.56 mg/l.

The coefficients of the annual and tidal components, the unexplained term, and 182.5 times the trend coefficient were ranked by magnitude. This is the ranking of expected

REGRESSION ANALYSIS
AUG. 1962 - JULY 1963
STATION 34S

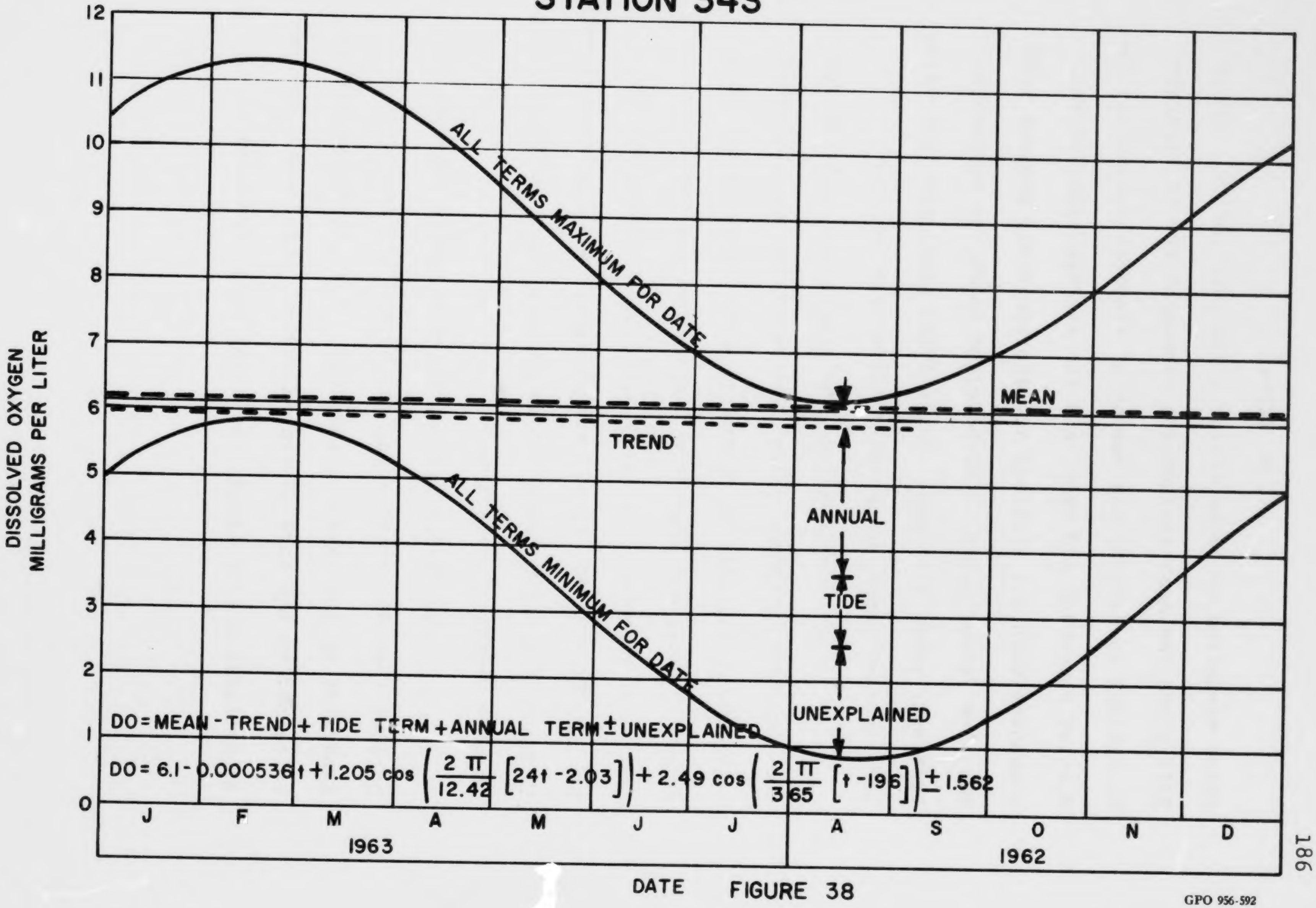


FIGURE 38

value variation or range during a one-year period. Table XVII gives the most predominant component for the maximum to minimum variation, the number of stations having the indicated component and rank, and the average value of the component when all stations are appropriately grouped into bay, New Jersey shore, Staten Island shore, or wastewater treatment plant stations. Table XVIII gives the base value and expected range of the parameters over one year.

After subtracting the regression estimate from the observed parameter value, the remainder was subjected to spectral analysis to determine what cycles, other than annual, tidal, and long-term, influenced the data. Ten lags were computed, representing periods of ∞ , 140, 70, 46, 35, 28, 23, 20, 17, 16 and 14 days. Results are presented in Table XIX, which shows those periods found to be significant in the remaining variation.

The 70-day period, which actually represents all periods from 46 to 140 days, may be the 133-day cycle generated by the sampling schedule. The 140-day period may be caused by the same generated cycle. The 28-day, however, is probably a true cycle, the lunar tidal component.

TABLE XVII

SUMMARY OF VARIATION FROM REGRESSION ANALYSIS

Parameter	Predominate Component Producing Max to Min Variation				No. of Stations Having Predominate Comp. & Variation Rank				Average Value of Component				
									L	A	T	U	Base
					Bay Stations (44) Grouped								
Air Temp. °C	A	U	L	T	44	44	32	32	1.38	12.71	0.761	3.39	12.39
Sample Temp. °C	A	U	L	T	44	44	31	31	0.63	11.31	0.39	1.35	12.4
D.O. mg/l	A	U	T	L	42	41	29	30	0.444	2.426	0.592	1.381	7.70
MF Strep 1/	U	A	T	L	31	26	28	36	0.264	0.933	0.657	1.233	4.05
MPN Coli 1/	U	T	A	L	35	24	31	37	0.318	0.628	0.932	1.251	6.551
MPN Fecal C. 1/	U	A	A* T	L	35	16	18	32	0.333	0.706	0.926	1.386	5.430
Chlorides mg/l	U	A	L	T	32	24	24	22	412	873	441	1057	13,312

1/ Expressed as natural log (loge) of density per 100 ml.
* = Tied Rank
L = Long term trend (182.5 x Trend Coef.)
A = Annual period cycle (Annual Coef.)
T = Tidal period cycle (Tide Coef.)
U = Unexplained variation

TABLE XVII (Cont.)

SUMMARY OF VARIATION FROM REGRESSION ANALYSIS

Parameter	Predominate Component Producing Max to Min Variation				No. of Stations Having Predominate Comp. & Variation Rank				Average Value of Component L	A	T	U	Base
					Staten Island Shore Stations (16) Grouped								
MF Strep	U	A	L	T	12	12	10	10	0.510	1.240	0.430	1.703	4.004
MPN C Coli	U	A	T	L	15	10	8	10	0.395	0.736	0.514	1.350	6.392
MPN Fecal C.	U	A	T	L	13	7	7	10	0.468	0.983	0.650	1.426	5.766
					New Jersey Shore Stations (16) Grouped								
MF Strep	U	A	T	L	15	12	8	9	0.500	1.053	0.435	1.754	4.012
MPN C Coli	U	A T	L	L	16	8 8	8	8	0.372	0.607	0.565	1.461	5.501
MPN Fecal C.	U	A	A	T	15	6	10	10	0.627	0.758	0.567	1.726	4.178
					Sewage Treatment Plants (8) Grouped								
MF Strep	U	A	$\frac{A}{T}$	$\frac{L}{T}$	7	4	3	4	0.827	0.951	0.499	1.823	4.389
MPN C C	U	A	A	$\frac{L}{T}$	6	4	4	4	0.900	1.475	0.685	2.466	4.849
MPN F C	U	L	A	T	7	4	5	1	0.925	0.768	0.549	2.026	3.019
BOD	U	A	T	L	6	4	4	5	11.47	21.98	14.78	45.89	145.12

TABLE XVIII

BASE AND EXPECTED RANGE VALUES OF SELECTED PARAMETERS

Parameter	Base Value	Expected Range Min	Expected Range Max
	Bay Stations		
Air Temp., °C	12.40	-5.84	30.64
Sample Temp., °C	12.4	-1.28	26.08
DO, mg/l	7.70	2.86	12.54
*MF Strep	54	3	1,260
*MPN Coli	700	30	16,000
*MPN Fec Coli	230	8	6,500
Cl^-, mg/l	13,312	10,529	16,095
	New Jersey Shore Stations		
*MF Strep	55	1	2,300
*MPN Coli	240	12	5,000
*MPN Fec Coli	65	2	2,600
	Staten Island Shore Stations		
*MF Strep	55	1	2,600
*MPN Coli	600	30	12,000
*MPN Fec Coli	320	9	11,000
	Sewage Treatment Plant Effluents		
*MF Strep	81	1	4,800
*MPN Coli	126	1	30,200
*MPN Fec Coli	20	1	1,400
BOD, mg/l	145.12	51.00	239.24

*Expressed as density per 100 ml.

TABLE XIX

SIGNIFICANT CYCLES BY SPECTRAL ANALYSIS

Station	Chloride Period, Days	Chloride % of Variation	D.O. Period, Days	D.O. % of Variation	MF Strep Period, Days	MF Strep % of Variation	MPN Coli Period, Days	MPN Coli % of Variation
7S	140	-	140	50	None	-	70	32
11S	70	41	28	42	None	-	None	-
13S	70	50	70	42	None	-	None	-
26S	70	52	None	-	None	-	None	-
34S	70	42	70	40	None	-	None	-
463S	70	37	70	44	None	-	70	48

Since the preceding analyses were based upon weekly samplings, no estimate could be made of the variations due to a 24-hour cycle. To estimate the magnitude of this component, data obtained from a 24-hour sampling operation were used. On June 27 and 28, 1963, samples were collected over a period of 24 hours at Stations 34 and 26, and at the dock of the Public Health Service Quarantine Station at the Narrows, Staten Island, New York. Hourly determinations were made of salinity, water temperature, dissolved oxygen, MPN, confirmed coliform and MPN fecal coliform. Fecal coliform and fecal streptococcus analysis by membrane filters were made at 30-minute intervals.

A Fourier Series analysis was performed on the data for periods of 24 and 12 hours, the daily and tidal cycles. Since the regression equation included the tidal cycle, a comparison of the tidal cycle calculated by both regression and Fourier Series serves to validate the use of the daily cycle found by the Fourier Series. Results of the Fourier Series analysis, and a comparison of the tidal component with that found by the regression equation are presented in Table XX.

Chlorination of Sewage Treatment Plant Effluents

In 1963 a cooperative study was undertaken by

TABLE XX

DAILY AND TIDAL COMPONENTS OF VARIATION BY FOURIER SERIES

	Daily (24-hr) Cycle		Tidal Cycle			
Station & Parameter	% of Variance	D_f	% of Variance	C_f	C_r 1/	$\frac{D_f}{C_f}$
26S						
D.O., mg/l	3.4	0.58	4.7	0.68	0.90	0.8
MF Strep*	31.1	0.94	3.6	0.32	0.31	2.94
MPN Coli*	6.4	0.49	48.2	1.36	1.60	0.36
MPN Fecal Coli*	20.5	0.85	52.8	1.37	1.83	0.62
Salinity, °/oo	32.4	0.07	20.0	0.05		1.28
34S						
D.O., mg/l	54.4	1.50	38.1	1.30	1.21	1.15
MF Strep*	66.6	1.74	19.1	0.94	1.12	1.85
MPN Coli*	62.3	1.62	4.3	0.43	0.96	3.77
MPN Fecal Coli*	51.5	1.45	10.7	0.66	1.17	2.20
Salinity, °/oo	3.3	0.01	41.0	0.05	-	0.27
Quarantine Dock						
D.O., mg/l	29.8	0.70	61.9	1.01	-	0.69
MF Strep*	57.4	1.38	13.4	0.67	-	2.06
MPN Coli*	5.2	0.28	30.2	0.68	-	0.41
MPN Fecal Coli*	11.5	0.48	58.8	1.08	-	0.44
Salinity, °/oo	1.6	0.02	81.1	0.12	-	0.17

Coefficient of tidal variation as calculated by regression analysis.

*C_f, C_r & D_f expressed as natural log of density per 100 ml.

the Project and New Jersey State Health Department to determine the effect of post-chlorination of primary treatment plant effluents on water quality of the westerly portion of Raritan Bay. Following the establishment of base line conditions by bacteriological analyses of the bay waters, effluent chlorination at nine plants discharging an average total of 59 MGD into the western area of Raritan Bay was halted simultaneously for a period of nine days and then resumed. Data collected during this study showed a significant increase in the bacterial population present in the bay following cessation of post-chlorination. Within six to 50 hours after cessation of chlorination, depending on station location, the bacterial population in the bay reached new stable levels significantly higher than those found during the base line study. Following resumption of post-chlorination there was a significant reduction in the bacterial population at most of the stations. *Salmonella* organisms were isolated from samples of unchlorinated plant effluent and from the waters receiving these discharges. The study concluded that post-chlorination of wastewater treatment plant effluent was an effective measure for reducing the total bacterial population and the occurrence of *Salmonella* in the waters of western Raritan Bay.

K. H. Walker

Shellfish Quality

Between August 1963 and August 1964 the Project conducted bacteriological analyses on 391 shellfish samples taken from 50 stations throughout Raritan Bay. Analyses were performed for MPN total coliform, MPN fecal coliform, and for the presence of Salmonella bacteria. The results are summarized in Table XXI.

Samples from 12 of the 50 stations had geometric mean total coliform densities greater than 2,400 per 100 grams. The geometric mean fecal coliform density in shellfish taken from these same 12 stations ranged from 610 to 16,000 per 100 grams. The presence of high total coliform densities appeared to show some correlation with water temperature. None of the shellfish taken from waters with temperatures less than 8.5°C had total coliform MPNs of 2,400 or more per 100 grams. The 12 stations having geometric mean coliform densities greater than 2,400 per 100 grams were located in the northerly sector of the bay in an area extending generally south of Staten Island to and across the New York-New Jersey State line.

Salmonella were isolated from clam meats collected at 14 of the 50 sampling stations. Of these 14

TABLE XXI

RESULTS OF BACTERIOLOGICAL EXAMINATION OF SHELLFISH MEATS

	Total Coliform, MPN/100g.				Fecal Coliform, MPN/100g.				Salmonella Isolations	
Station	No.	Min	Max	Geom Mean	No.	Min	Max	Geom Mean	No.	Serotypes
1	8	< 20	490	180	8	< 20	330	120		
2	8	< 20	1,700	550	8	< 20	460	140		
3	8	< 20	2,300	700	8	< 20	2,300	370		
4	9	< 20	24,000	3,200	9	< 20	7,900	970		
6	7	< 20	17,000	5,700	7	< 20	13,000	3,100	4	S.st. paul; S.anatum; S.montevideo; S.litchfield
7	8	< 20	160,000	39,000	8	< 20	92,000	16,000	2	S.oranienburg; S.derby
10	7	< 20	35,000	8,700	7	< 20	11,000	2,600	2	S.derby; S.infantis
13	6	< 20	7,900	1,400	6	< 20	2,300	410		
14	8	< 20	330	100	8	< 20	130	45		
15	8	< 20	330	120	8	< 20	20	20		
16	8	< 20	330	120	8	< 20	230	52		
17	9	< 20	2,300	580	9	< 20	790	210		
18	7	< 20	4,900	1,600	7	< 20	1,300	350		
20	7	< 20	13,000	4,000	7	< 20	2,300	1,100		
21	6	< 20	13,000	4,900	6	< 20	3,300	1,300	1	S.derby
22	8	< 20	3,300	1,200	8	< 20	3,300	740	1	S.derby
23	8	< 20	7,000	1,400	8	< 20	790	260		
24	8	< 20	4,900	1,300	8	< 20	1,300	280		
25	9	< 20	35,000	5,700	9	< 20	3,300	1,000	1	S.tennessee
26	9	< 20	16,000	2,800	9	< 20	3,500	610		
27	8	< 20	3,300	1,000	8	< 20	2,200	620		
28	8	< 20	1,300	600	8	< 20	490	160	1	S.derby
29	7	< 20	790	260	7	< 20	490	110		
30	7	< 20	460	200	7	< 20	170	71		
31	8	< 20	460	210	8	< 20	230	95		
32	8	< 20	7,900	1,400	8	< 20	950	320		
33	7	< 20	2,300	930	7	< 20	790	350		
36	8	< 20	92,000	13,600	8	< 20	35,000	4,700	1	S.derby

TABLE XXI (Cont.)

RESULTS OF BACTERIOLOGICAL EXAMINATION OF SHELLFISH MEATS

Station	No.	Min	Total Coliform, MPN/100g. Max	Geom Mean	Fecal Coliform, MPN/100g. No.	Min	Max	Geom Mean	Salmonella Isolations No.	Serotypes
37	7	< 20	24,000	6,600	7	< 20	4,900	1,700	1	S.anatum
39	9	< 20	24,000	5,200	9	< 20	24,000	3,500	1	S.6,7:K mono.
40	8	< 20	22,000	5,600	9	< 20	7,900	2,100	3	S.derby; S.anatum; S.6,7 non.mot.
41	9	< 20	3,300	1,100	9	< 20	490	150		
42	8	< 20	3,500	540	8	< 20	310	70		
43	7	< 20	490	150	7	< 20	140	67		
44	8	< 20	2,300	630	8	< 20	230	77		
45	7	< 20	490	190	7	< 20	140	52	1	S.typhimurium
46	8	< 20	230	97	8	< 20	80	31		
47	8	< 20	1,300	350	8	< 20	230	76	2	S.6,7:mon.mot; S.6,7:K mono.
48	8	< 20	3,300	780	8	< 20	790	150		
49	8	< 20	13,000	2,000	8	< 20	1,300	300		
50	8	< 20	3,300	600	8	< 20	490	92		
51	7	< 20	2,300	400	7	< 20	2,300	340		
52	7	< 20	4,900	860	7	< 20	460	110		
53	8	< 20	2,100	380	8	< 20	130	37		
54	7	< 20	7,900	1,300	7	< 20	490	90		
56	7	< 20	490	180	7	< 20	170	44		
57	8	< 20	4,900	820	8	< 20	490	160	2	S.infantis; S.muenchen
58	6	< 20	3,300	1,200	6	< 20	230	120		
61	6	110	7,000	1,400	6	< 20	4,600	820		
73	6	< 20	2,300	400	6	< 20	170	45		

stations, nine also showed geometric mean total coliform densities greater than 2,400 per 100 grams of clam meat. The geometric mean coliform density in shellfish from the other five stations ranged from 180 to 1,200 per 100 grams. A total of 23 Salmonella isolations were made with 13 serotypes identified. Salmonella derby was the predominant serotype and was isolated in shellfish from seven of the 14 stations. Stations which showed the presence of Salmonella in the clam meats covered two general areas, one of which corresponded with the location of high coliform counts in the clam meats as described above. The second area was located along the New York-New Jersey State line, in an area bounded roughly by Seguine Point, Great Kills, Staten Island, New York, and Keyport and Keansburg, New Jersey.

Chemical analyses of meats from shellfish taken from these 50 sampling stations were performed by the Public Health Service's Northeastern Shellfish Sanitation Research Center. The complete report of this agency is contained in Volume III - Appendices of this report. High phenol and mineral oil concentrations were found in shellfish meats taken from a number of stations in the western sector of the bay, with highest values associated with those stations nearest the mouths of the Arthur Kill and Raritan River. Specific analyses for a number of metals, including copper, chromium, zinc and lead, and for pesticide residues, revealed trace amounts in clam meats.

Pathogen Isolations from Sewage and Bay Waters

In an attempt to further evaluate the effects of Upper Bay and the Narrows on the eastern portion of Raritan Bay, studies were undertaken to isolate *Salmonella* and *Shigella* from sewers discharging into the Narrows, and from the waters of Raritan Bay and the Narrows. Isolations obtained are presented in Tables XXII through XXV. Figure 39 identifies the location of those sampling points where Salmonella isolations were successful.

No isolations could be made of *Shigella* organisms but a number of positive results were obtained for *Salmonella.* From October 1963 through April 1964, these organisms were isolated in four of seven samples taken from the Nautilus Street sewer, which discharges raw municipal wastes from Staten Island into Upper Bay just above the Narrows. Between October 1963 and July 1964, a total of 20 samples in the Narrows were analyzed, 40 percent of which were positive for *Salmonella.* A total of 15 different serotypes were identified, and as many as seven different serotypes were isolated from one sample.

TABLE XXII

SALMONELLA ISOLATED FROM THE NAUTILUS STREET PIPE DISCHARGING RAW SEWAGE INTO THE NARROWS

Date	*Salmonella* Serotypes Isolated (Gauze-Pad Technic)
16 October 1963	*Salmonella cubana*
4 November 1963	Negative
17 March 1964	Negative
23 March 1964	*S. derby*
	S. bredeney
31 March 1964	*S. derby*
13 April 1964	Negative
21 April 1964	*S. bredeney*

TABLE XXIII

SALMONELLA ISOLATED FROM THE NARROWS IN THE AREA OF THE NAUTILUS STREET OUTFALL

Date	*Salmonella* Serotypes Isolated
16 October 1963	+ Negative
25 October 1963	Negative
28 October 1963	Negative
4 November 1963	Negative
10 February 1964	*S. typhimurium*
	S. livingstone
	S. derby
2 March 1964	*S. tennessee*
3 March 1964	*S. montevideo*
	S. heidelberg
11 March 1964	*S. montevideo*
	S. enteriditis
	S. oranienburg
	S. derby
17 March 1964	S. 6,7: non-motile (variant)
	S. 6,7: K monophosic (variant)
23 March 1964	*S. derby*
	S. java
	S. oranienburg
	S. bredeney
	S. typhimurium

TABLE XXIII (Cont.)

SALMONELLA ISOLATED FROM THE NARROWS IN THE AREA OF NAUTILUS STREET OUTFALL

Date	*Salmonella* Serotypes Isolated
	S. infantis
	S. anatum
31 March 1964	*S. muenchen*
	S. infantis
13 Apr[illegible] 1964	Negative
21 April 1964	*S. heidelberg*
	S. montevideo
	S. oranienburg
8 June 1964	x Negative
10 June 1964	Negative
15 June 1964	Negative
20 June 1964	Negative
26 June 1964	Negative
7 July 1964	Negative
15 July 1964	Negative

+ = Samples from 16 October 1963 to 21 April 1964 were collected by the gauze-pad technique.

x = From 8 June 1964 to 15 July 1964 samples were processed by filtering 2 liters of sample water through diatomaceous earth.

TABLE XXIV

RESULTS OF BACTERIOLOGICAL ANALYSES PERFORMED ON SAMPLES COLLECTED AT SOUTH BEACH, MIDLAND BEACH, AND MILLER FIELD BEACH, STATEN ISLAND

Sample Station (See Fig.39 for Location)	Date	x Salmonella Isolates	MPN/100 ml Coliforms	MPN/100 ml Fecal Coli.
South Beach 1 (Ocean Ave.) 15 ft. from shore	28 July 1964	Negative	7,900	4,900
	4 Aug 1964	*S. st. paul*	4,900	2,300
	10 Aug 1964	Negative	17,000	7,900
South Beach 1 200 ft. from shore	16 July 1964	*S. st. paul*	49,000	3,300
	28 July 1964	Negative	24,000	4,900
	4 Aug 1964	*S. montevideo*	168,000+	7,900
	10 Aug 1964	Negative	17,000	11,000
South Beach 2 (Center of Beachland Lane) 15 ft. from shore	28 July 1964	Negative	3,300	790
	4 Aug 1964	Negative	11,000	630
	10 Aug 1964	Negative	17,000	13,000
South Beach 2 200 ft. from shore	28 July 1964	Negative	4,900	1,700
	4 Aug 1964	*S. st. paul*	7,900	1,400
	10 Aug 1964	*S. montevideo*	13,000	4,900
Midland Beach 1 (Graham Blvd.) 15 ft. from shore	24 July 1964	Negative	9,200	4,600
	28 July 1964	Negative	330	33
	4 Aug 1964	Negative	330	330
	10 Aug 1964	Negative	9,200	5,400
Midland Beach 1 200 ft. from shore	16 July 1964	Negative	-	-
	28 July 1964	Negative	230	50
	4 Aug 1964	*S. st. paul*	16,000	9,200
	10 Aug 1964	Negative	4,900	490

TABLE XXIV (Cont.)

RESULTS OF BACTERIOLOGICAL ANALYSES PERFORMED ON SAMPLES COLLECTED AT SOUTH BEACH, MIDLAND BEACH, AND MILLER FIELD BEACH, STATEN ISLAND

Sample Station (See Fig. 39 for Location)		Date	x Salmonella Isolates	MPN/100 ml Coliforms	MPN/100 ml Fecal Coli.
Midland Beach 2 (Midland Ave.)					
15 ft. from shore		28 July 1964	Negative	200	46
		4 Aug 1964	Negative	230	33
		10 Aug 1964	*S. typhimurium*	1,300	490
Midland Beach 2					
200 ft. from shore		28 July 1964	Negative	50	20
		4 Aug 1964	Negative	790	330
		10 Aug 1964	Negative	490	330
Miller Field					
Beach	1	24 July 1964	Negative	330	130
	2	24 July 1964	Negative	230	33
	3	24 July 1964	Negative	330	49
	4	24 July 1964	Negative	490	79

x = For Salmonella isolations - 2 liters of sample water were filtered through diatomaceous earth.

+ = greater than

TABLE XXV

RESULTS OF BACTERIOLOGICAL ANALYSES PERFORMED ON SAMPLES COLLECTED IN RARITAN BAY

Station (Navigational Aid)	Date	Salmonella by Gauze Pad	Isolations by Filtration (2L)	MPN/100 ml Coliforms	MPN/100 ml Fecal Col.
23 Bell	18 May '64	-	Negative	-	-
	22 May '64	Negative	-	-	-
	2 June '64	Negative	-	-	-
3 Gong	18 May '64	-	(variant) *S.1,3,19 mon-motile*	-	-
	22 May '64	Negative	-	-	-
	2 June '64	*S. derby* *S. montevideo* *S. anatum* *S. litchfield*	-	-	-
19 Can	17 June '64	-	Negative	-	-
	24 June '64	*S. derby*	Negative	-	-
	8 July '64	-	Negative	-	-
19A Bell	18 May '64	-	*S. anatum*	-	-
	22 May '64	Negative	-	-	-
	2 June '64	*S. derby* *S. anatum*	-	-	-
39 B & W Bell (black & white)	18 May '64	-	Negative	-	-
	22 May '64	Negative	-	-	-
	2 June '64	*S. montevideo*	-	-	-
17 Whistle	17 June '64	-	Negative	-	-
	24 June '64	Negative	*S. derby*	-	-
	8 July '64	-	*S. infantis* *S. derby*	-	-
17 Bell	17 June '64	-	Negative	-	-
	24 June '64	Negative	Negative	-	-
	8 July '64	Negative	Negative	-	-
	16 July '64	*S. st. paul*	-	-	-
15 Buoy	17 June '64	-	Negative	-	-
	24 June '64	Negative	Negative	-	-
	1 Sept '64	-	Negative	3,300	340
	11 Sept '64	-	Negative	460	60

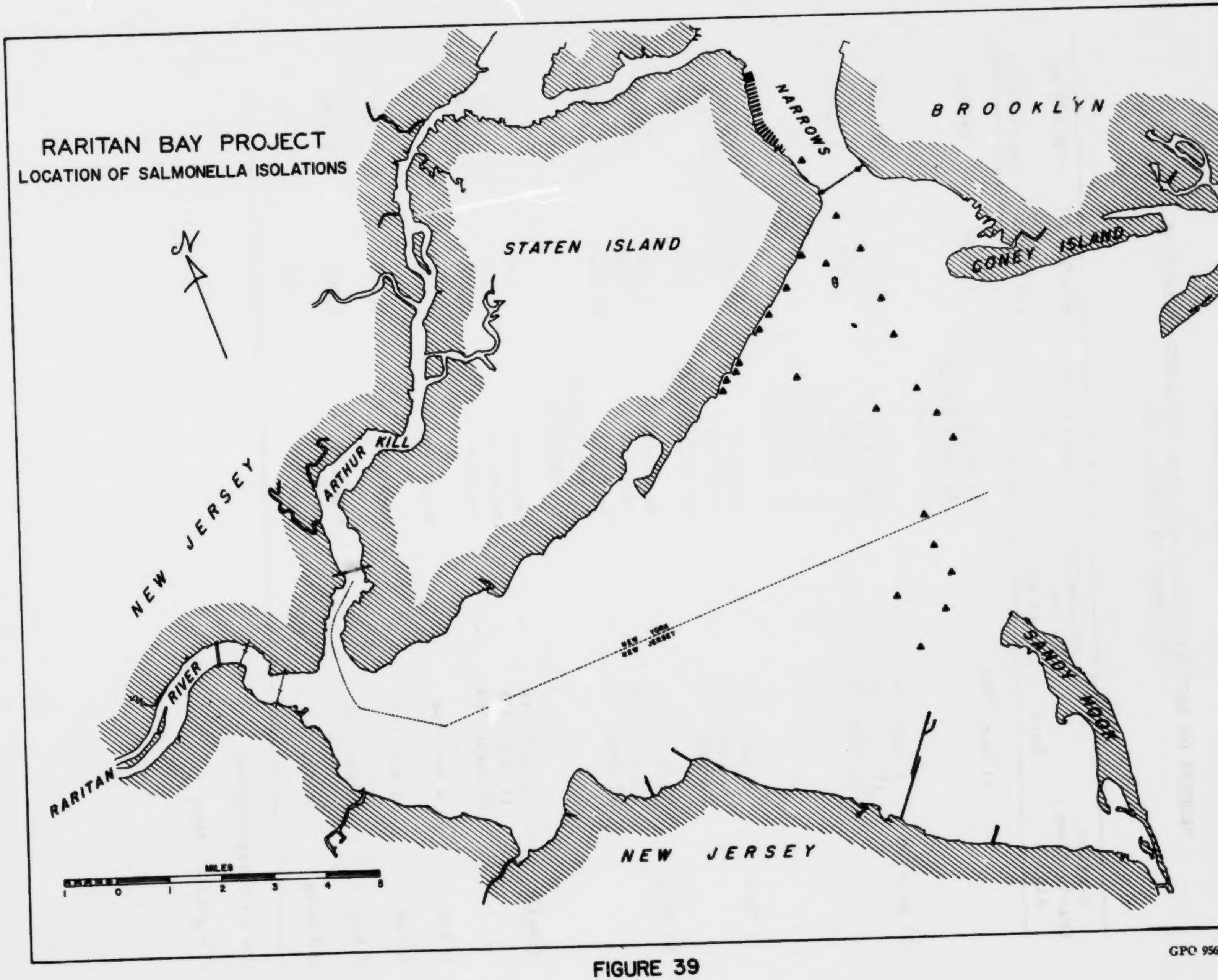
TABLE XXV (Cont.)

RESULTS OF BACTERIOLOGICAL ANALYSES PERFORMED ON SAMPLES COLLECTED IN RARITAN BAY

Station (Navigational Aid)	Date	Salmonella by Gauze Pad	Isolations by Filtration(2L)	MPN/100 ml Coliforms	MPN/100 ml Fecal Coli.
	21 Sept '64	-	*S. derby* *S. heidelberg* *S. blockley*	16,000+	16,000
13 Whistle	1 Sept '64	-	Negative	24,000	13,000
	11 Sept '64	-	Negative	490	230
	21 Sept '64	-	*S. derby* *S. st. paul* *S. oranienburg* *S. newport*	5,400	3,500
11 Buoy	1 Sept '64	-	Negative	92,000	54,000
	11 Sept '64	-	Negative	490	230
	21 Sept '64	-	*S. typhimurium*	230	230
10 Bell	1 Sept '64	-	Negative	9,200	3,500
	11 Sept '64	-	Negative	230	79
	21 Sept '64	-	*S. derby* *S. heidelberg* *S. muenchen*	16,000+	9,200
5 Bell	1 Sept '64	-	Negative	790	170
	11 Sept '64	-	Negative	330	170
	21 Sept '64	-	Negative	2,800	1,400
4 Nun	4 Nov '64	-	Negative	490	330
6 Nun	4 Nov '64	-	Negative	1,300	490
8 Nun	4 Nov '64	-	Negative	9,200	2,100
R&B Gong	4 Nov '64	-	Negative	230	11

- = No determination

+ = greater than



RARITAN BAY PROJECT
LOCATION OF SALMONELLA ISOLATIONS

N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
SANDY HOOK
NEW JERSEY
MILES
1 0 1 2 3 4 5

FIGURE 39

K. H. Walker

Areas of Staten Island shore closest to the Narrows showed the greatest frequency of Salmonella isolation. Five of 13 samples taken at South Beach were positive; at Midland Beach two of 14 samples showed Salmonella. No Salmonella were recovered from samples further west at the Miller Field beach areas. Some of the same serotypes found in the Narrows were isolated from the bathing area samples. Although a limited number of samples were analyzed, the relatively small sample volume (2 liters) which was used for these determinations suggests a substantial density in these areas.

Attempts were made to isolate Salmonella from various locations in eastern Raritan Bay (See Figure 39) extending on a line from the Narrows southerly towards Sandy Hook. Of the 16 stations sampled, 10 were positive. Of the 48 samples processed, 27 percent contained Salmonella, and a total of 25 Salmonella isolations were made. S. derby was the predominant serotype, being isolated on eight different occasions, and was also the predominant serotype in the samples collected at the Narrows. Salmonella were isolated below the Narrows as far as No. 10 Bell, approximately six miles south of the Verrazzano-Narrows Bridge.

This completes my presentation on the analytical results. I turn the report back to Mr. DeFalco.

FURTHER STATEMENT OF PAUL DE FALCO, JR., DIRECTOR, RARITAN BAY PROJECT, FEDERAL WATER POLLUTION CONTROL ADMINISTRATION, DEPARTMENT OF THE INTERIOR, METUCHEN, NEW JERSEY

MR. DE FALCO: Gentlemen, if you can turn to the summary document for the conclusions and recommendations?

CONCLUSIONS

1. Raritan Bay and Arthur Kill are interstate waters within the meaning of 33 USC 466 et seq. Raritan River, a major tributary, is included in the conference area because of its effects on the bay. Pollution results from the direct discharge of municipal and industrial wastes, as well as by wastes carried into the area from Upper Bay. Originating in the States of New York and New Jersey, this pollution endangers the health and welfare of persons living in both States and is subject to abatement under 33 USC et seq.

2. The primary cause of pollution of the eastern section of Raritan Bay is the transfer of untreated and inadequately treated wastes from Upper Bay through the Narrows.

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Recommendations by "Conference in the Matter of Pollution of the Interstate Waters of the Hudson River and its Tributaries -- New York and New Jersey" pertain to these waste sources.

3. The major cause of pollution of the western section of Raritan Bay is the direct discharge of raw and inadequately treated municipal wastes.

4. Additional pollution in the western section results from the interchange of these waters with the polluted Raritan River and Arthur Kill.

5. Arthur Kill is polluted by the discharge of raw or inadequately treated industrial and municipal wastes. Limited circulation in this waterway results in grossly polluted conditions.

6. Many existing municipal wastes treatment facilities are outdated, overloaded or inadequately maintained. Poor operation by unlicensed and untrained personnel adds to the problem. The State of New Jersey and the City of New York, in cooperation with the Interstate Sanitation Commission, have placed the major polluters under formal abatement orders.

7. New York, New Jersey and the Interstate Sanitation Commission have classified the waters of the study

area. While these classifications, which are based on best use of the waters, may not agree in all cases there seems to be no reason why the highest water quality proposed by any one of the three agencies should not be adopted by all. Selection of the highest criteria would provide for the safe use of the Arthur Kill for recreational boating.

8. Plans or construction are under way for improved wastes treatment facilities for a number of sources in both States.

9. Commercial boating is not at present a serious source of pollution in the open waters, but may present local problems in berthing areas.

10. Pleasure boating, although a major water use affected by pollution of the Raritan Bay, is also a measurable contributor to pollution.

11. Major benefits will accrue in recreational bathing from the clean-up of these waters.

12. Additional major benefits would accrue if the quality of these waters were at the level necessary to support a safe shellfishery.

RECOMMENDATIONS

On the basis of Project studies the following

Paul DeFalco

recommendations are made in order to reclaim study area waters for maximum beneficial uses:

1. Treatment facilities provide a minimum of 90 percent removal of BOD and suspended solids, and effective year-round disinfection (effluent coliform count of no greater than one per ml in more than 10 percent of samples examined) at all municipal plants discharging directly to these waters. Program to be carried out in accordance with following time schedule:

   a. Complete plant design no later than December 1, 1967;
   b. Initiate construction no later than June 1, 1968;
   c. Place in operation no later than June 1, 1970;

unless existing orders specify completion dates earlier than the above, in which case the earlier dates must be met.

2. Industrial plants shall improve practices for the segregation and treatment of wastes so as to effect maximum reduction of the following:

   a. Acids and alkalis;
   b. Oil and tarry substances;
   c. Phenolic and other compounds that contribute to taste, odor and tainting of fin and shellfish meat.

d. Nutrient materials, including nitrogenous and phosphorous compounds;

e. Suspended material;

f. Toxic and highly colored wastes;

g. Oxygen requiring substances;

h. Heat;

i. Foam producing discharges

j. Bacteria;

k. Wastes which detract from optimum use and enjoyment of receiving waters.

Industrial treatment facilities to accomplish such reduction must provide removals at least the equivalent of those required for municipal treatment plants. Such facilities or reduction should be provided in accordance with the following time schedule:

a. Completion of engineering studies and design by December 1, 1967;

b. Commence construction by June 1, 1968;

c. Place in operation by June 1, 1970;

unless existing orders specify compliance dates earlier than the above, in which case the earlier dates must be met.

3. Qualified resident operators (licensed or certified) be provided at each treatment plant.

4. Facilities and procedures be established at each treatment facility to provide laboratory control.

5. Automatic instrumentation and recorders be required for flow and chlorination feed or residual control to permit prompt and effective supervision by plant operators and water pollution control agencies.

6. Priority for construction grants be established so affected communities may obtain funds to meet the requirements outlined above.

7. Recognition be given to the problems which will arise as a result of the continued population growth in the area, which may lead to the necessity for tertiary or other advanced wastes treatment techniques. All new facilities should be planned with sufficient site space to permit future expansion for such treatment.

8. State regulations be extended to require wastes treatment facilities or holding tanks on all vessels and recreational boats using the area. If holding tanks are to be used, adequate dockside facilities be required to ensure proper disposal of wastes.

9. Conferees to meet every six months to review and initiate progress on water quality improvements.

10. Conferees will investigate additional proposals to safeguard water quality in the study area, to include but not be limited to:

a. Possible relocation of the main shipping channel through Raritan Bay to improve circulation characteristics;

b. Selection of areas for dredging for construction materials;

c. Suitable outfall locations for waste effluents to include possible trunk systems to divert effluents from the Arthur Kill.

INTRODUCTION

The Federal Water Pollution Control Act, as amended (33 USC 466 et seq) provides that pollution of interstate waters which endangers the health or welfare of any person is subject to abatement under procedures described in Section 10 (33 USC 466g) of the Act.

On the basis of reports, surveys and studies the Surgeon General of the Public Health Service, having reason to believe that pollution of the interstate waters of Raritan Bay and adjacent waters was endangering the health and welfare of persons in the State of New York and New Jersey, called a conference on the pollution of these waters. At the first session in August 1961, conferees requested a study by the Public Health Service to obtain scientific data for further control of pollution. Accordingly, the

Raritan Bay Project was established to carry out such a program. A second session of the conference was held in May 1963. At that time the Project reviewed its activities through December 1962 and was requested by the conferees to continue its studies to completion. On January 1, 1966, Congress transferred water pollution control activities from the Public Health Service to the Federal Water Pollution Control Administration. In May 1966, a Presidential reorganization transferred the Administration to the Department of the Interior, which has continued the Raritan Bay Project.

The Project study area, shown in Figures 1 and 2, includes Raritan, Lower and Sandy Hook Bays -- collectively referred to in this report as Raritan Bay, the Arthur Kill, and the Raritan River from its mouth to the confluence of the Millstone River in Manville, New Jersey. In addition, the Project carried out investigations in Upper Bay since pollution of that water was found to be a contributing factor to the water quality in the study area.

The 1965 population in the five counties immediately adjacent to Raritan Bay was 2.2 million persons. Projections indicate that by 1985 it will increase to 4.3 million, plus an additional 1.0 million persons in western Brooklyn, New York. Hence, more than 5.0 million people will

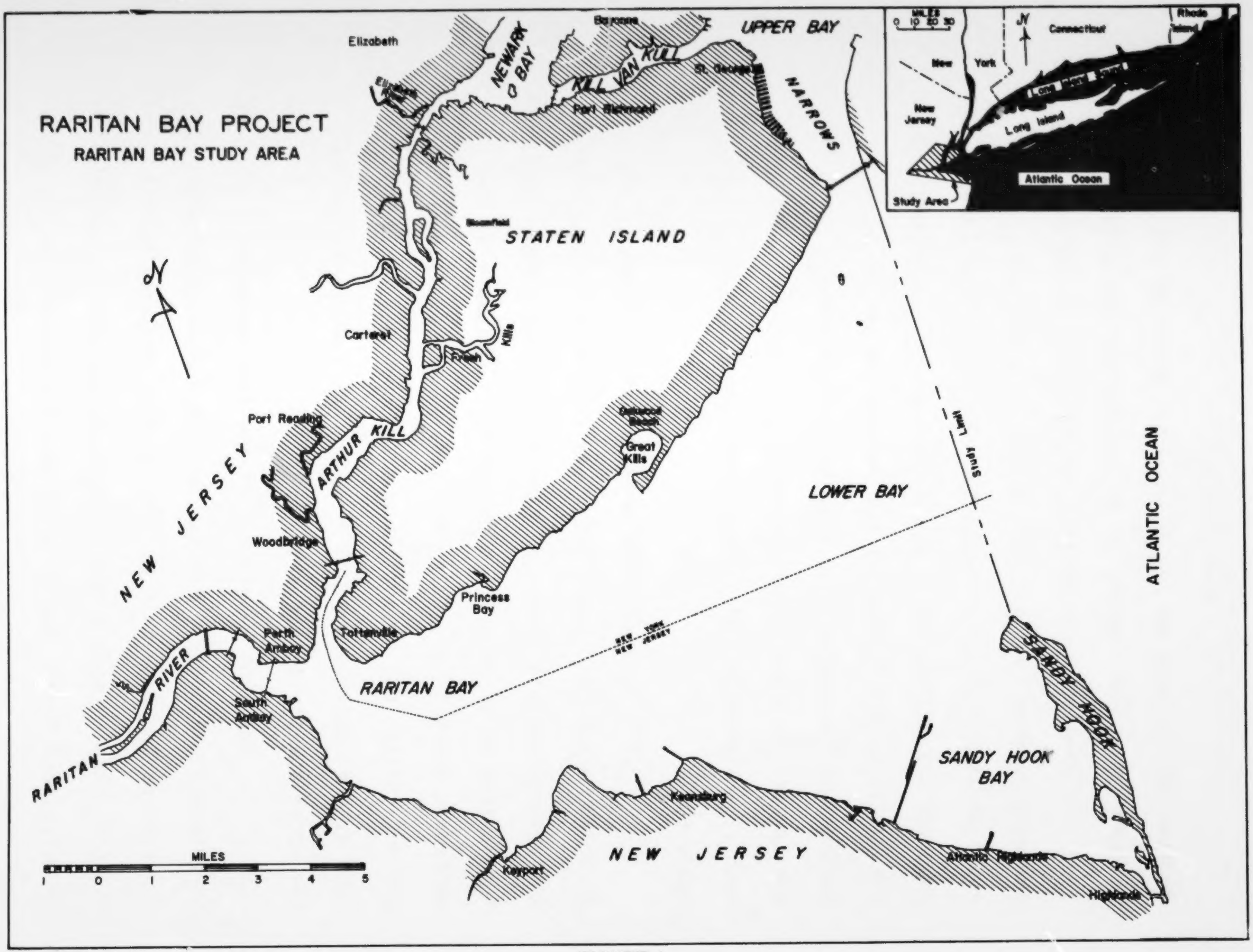

RARITAN BAY PROJECT
RARITAN BAY STUDY AREA
N
Elizabeth
NEWARK BAY
Bayonne
KILL VAN KULL
UPPER BAY
St. George
Port Richmond
NARROWS
Bloomfield
STATEN ISLAND
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
Woodbridge
NEW JERSEY
Great Kills
Princess Bay
Tottenville
Perth Amboy
South Amboy
RARITAN RIVER
RARITAN BAY
NEW YORK
NEW JERSEY
LOWER BAY
Study Limit
ATLANTIC OCEAN
SANDY HOOK
SANDY HOOK BAY
Keansburg
Keyport
Atlantic Highlands
Highlands
NEW JERSEY
MILES
1 0 1 2 3 4 5
MILES
0 10 20 30
New York
Connecticut
Rhode Island
New Jersey
Long Island Sound
Long Island
Atlantic Ocean
Study Area

FIGURE I

GPO 955-949

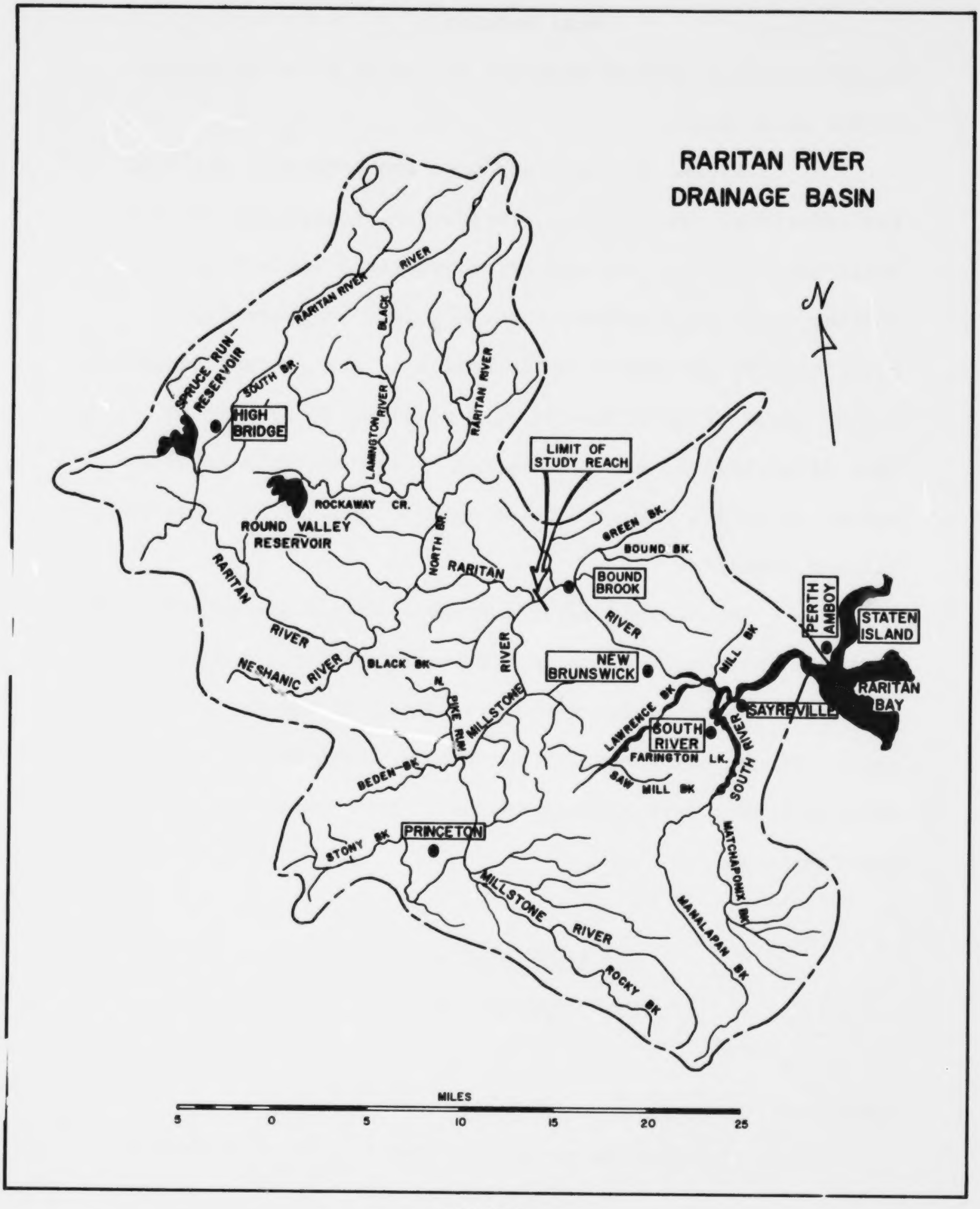

RARITAN RIVER
DRAINAGE BASIN
N
SPRUCE RUN RESERVOIR
HIGH BRIDGE
SOUTH BR.
RARITAN RIVER
BLACK RIVER
LAMINGTON RIVER
RARITAN RIVER
ROCKAWAY CR.
ROUND VALLEY RESERVOIR
NORTH BR.
RARITAN
LIMIT OF STUDY REACH
GREEN BK.
BOUND BK.
BOUND BROOK
RIVER
RARITAN RIVER
NESHANIC RIVER
BLACK BK.
N.
PIKE RUN
MILLSTONE RIVER
NEW BRUNSWICK
MILL BK
PERTH AMBOY
STATEN ISLAND
RARITAN BAY
SAYREVILLE
LAWRENCE BK
SOUTH RIVER
FARINGTON LK.
SAW MILL BK
SOUTH RIVER
BEDEN BK
STONY BK.
PRINCETON
MILLSTONE RIVER
ROCKY BK
MATCHAPONIX BK
MANALAPAN BK
MILES
5
0
5
10
15
20
25

FIGURE 2

GPO 955-949

be conveniently located adjacent to, or in close proximity to the study area.

Waters of the study area are presently utilized for industrial water supply, navigation, commercial fin and shellfishing, and a variety of recreational activities. However, full utilization of these waters is presently restricted by unsuitable water quality. The present estimated annual value of water use is $2.0 million; 90 percent of that is associated with recreation. With suitable quality, future potential value of these waters could be at least $19 million annually.

Studies of water currents and dispersion patterns indicate that Raritan Bay is affected by materials discharged into waters outside the immediate limits of the Project study area. Hence, any control program must consider the study area as a part of a system which includes Upper Bay, Kill Van Kull and Newark Bay.

WASTE DISCHARGES

RARITAN BAY

Municipal

Raritan Bay presently receives the discharge of treated and untreated municipal wastes from more than 500,000 persons. Untreated wastes from 3,000 people are discharged from Tottenville, Staten Island, New York. More than 80 percent of the remaining population is served only by primary treatment plants. Adequate disinfection of these wastes is not provided at all times due to inadequate maintenance and operation. Sources of municipal and institutional wastes, shown in Figure 3, are as follows:

No Treatment

Tottenville, Staten Island, New York

Primary Treatment

Highlands, N.J. (887)

Atlantic Highlands, N.J. (884)

Keansburg, N. J. (878)

Keyport, N. J. (875)

Matawan Borough, N.J. (869)

Madison Township, N.J. (866)

Sayreville - Morgan, Sayreville, N.J. (863)

South Amboy, N.J. (860)

Middlese County Sewerage Auth., Sayreville, N. J. (854)

Perth Amboy, N.J. (842)

Mount Loretto Home, Princess Bay, Staten Island, N. Y. (818)

Richmond Memorial Hosp. Princess Bay, Staten Island, N. Y. (812)

Daytop Lodge, Princess Bay Staten Island, N.Y. (880)

Intermediate Treatment

St. Joseph's by the Sea, Huguenot, Staten Island, N. Y. (806)

Secondary Treatment

Matawan Township, N.J. (872)

Matawan Township #3, Cliffwood Beach, N.J. (877)

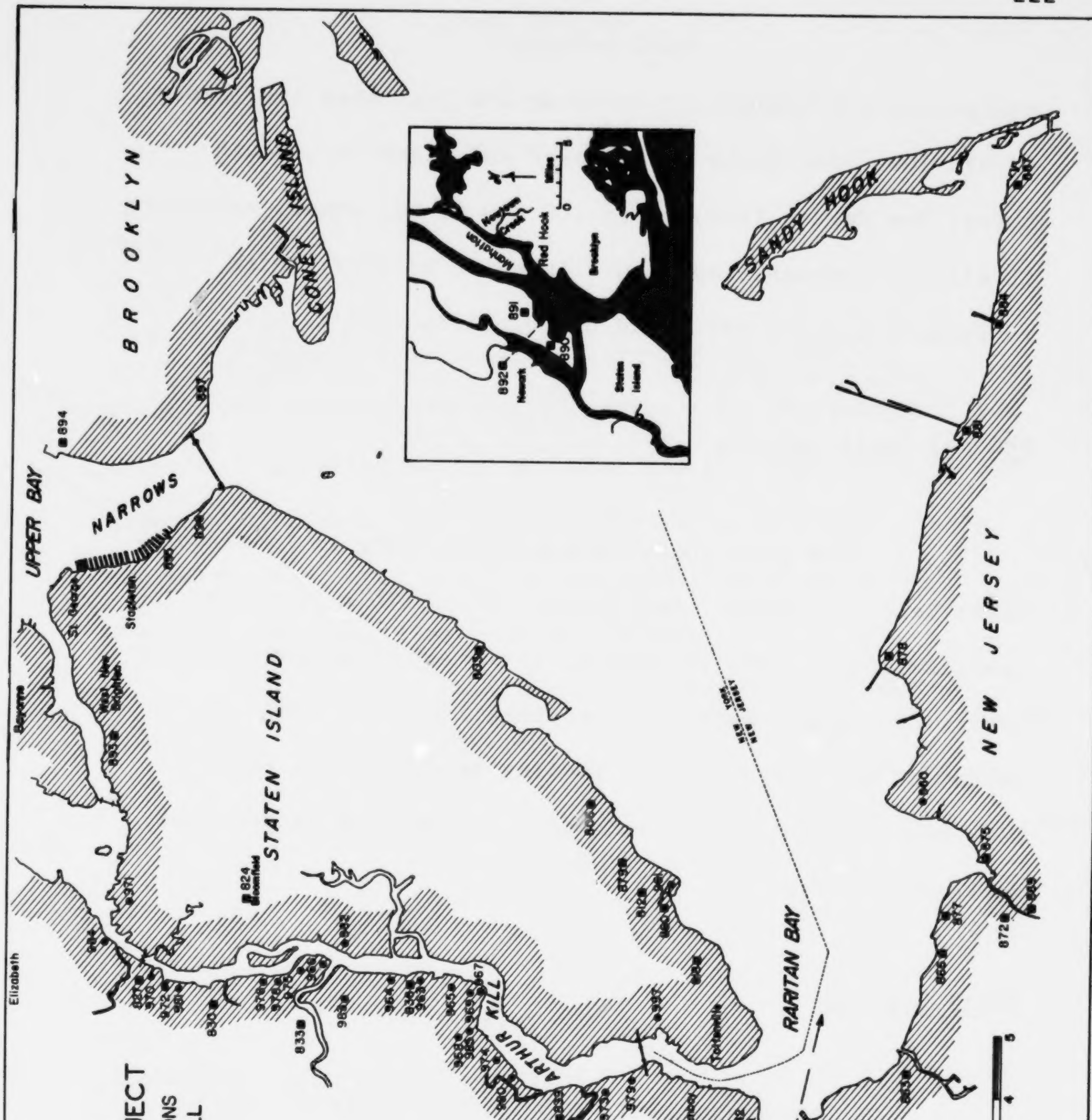
Junior High School #7, Huguenot, Staten Island, N. Y. (879)

Oakwood Beach, Staten Island, N.Y. (803)

These raw and treated sources represent an average flow of 72 MGD and loadings of 182,000 lbs/day of BOD and 40,000 lbs/day of suspended solids to Raritan Bay. More than 90 percent of the BOD load is from one source -- Middlesex County Sewerage Authority.

Industrial

Industrial wastes emanate from three sources. (See Figure 3.) International Flavors and Fragrances, Inc., Union Beach, New Jersey (960), discharges on an intermittent basis 2,500 lbs/day of BOD. The S. S. White Co., Princess Bay, Staten Island, New York (961), discharges wastes



RARITAN BAY PROJECT

WASTE SOURCE LOCATIONS
RARITAN BAY, ARTHUR KILL
& UPPER BAY

UPPER BAY
NARROWS
BROOKLYN
CONEY ISLAND
STATEN ISLAND
St. George
Stapleton
West New Brighton
Bayonne
Elizabeth
Bloomfield
824
ARTHUR KILL
Tottenville
Perth Amboy
RARITAN BAY
RARITAN RIVER
NEW JERSEY
SANDY HOOK
Newark
Manhattan
Red Hook
Brooklyn
Staten Island
892
891
890
894
977
833
830
LEGEND
● INDUSTRIAL WASTE SOURCE
■ MUNICIPAL WASTE SOURCE
MILES
0
1
2
3
4
5

FIGURE 3

GPO 955-949

containing 2.0 lbs/day of chromium and less than 1.0 lb/day of cyanide. The South Amboy Power and Light Co., South Amboy, New Jersey (962), uses 100 MGD of bay water, returning it with an average temperature increase of 10°F, which represents a daily heat load of 80 billion BTU's.

Federal Installations

The only installation discharging is Leonardo Naval Depot, Leonardo, New Jersey (881). This facility, handling wastes from 75 people, is served by an intermediate treatment plant. Loading is estimated at less than 1.0 lb/day of BOD. At the dock loading area chemical toilets have replaced privies serving crew members and laborers of dockside vessels.

Total Loadings

The waters receive 185,000 lbs/day of BOD. Although the tributary population is only 500,000, this loading is equivalent to the discharge of raw sewage from 1,084,000 people. This loading is due to high volumes of industrial wastes discharged to many of the municipal plants, in particular, Middlesex County Sewerage Authority.

ARTHUR KILL

Municipal

The Arthur Kill receives the discharge of treated and untreated municipal wastes from more than 831,000 persons. Untreated wastes emanate from the Bayway and Singer areas of Elizabeth, New Jersey. Sewage is provided primary treatment only, with chlorination practiced at only two of the five municipal plants in New Jersey.

Sources of municipal and institutional wastes (See Figure 3) are as follows:

No Treatment

Elizabeth, N. J.

Primary Treatment

Woodbridge - Sewaren, N. J. (839)

Carteret, N. J. (836

Rahway Valley, Rahway, N. J. (833)

Joint Meeting, Elizabeth, N. J. (827)

Linden - Roselle, Linden, N. J. (830)

Willowbrook State School, Staten Island, N. Y. (824)

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These seven sources represent an average flow of nearly 82 MGD, and discharge more than 138,000 lbs/day of BOD and 55,000 lbs/day of suspended solids.

Industrial

Untreated or partially treated wastes from 21 industries and three power generating stations are discharged to the kill (see Figure 3). The listing which follows identifies sources and extent of treatment provided. Many industries provide some treatment to at least a portion of their wastes, or discharge at least partially to municipal systems; therefore, such industries are classified as providing partial treatment.

No Treatment

American Agricultural Co., Carteret, N. J. (963)
FMC Corp., Carteret, N. J. (964)
Reichhold Chemicals, Inc., Carteret, N. J. (965)
American Cyanamid Co., Linden, N. J. (966)
Armour Agricultural Chemical Co., Carteret, N. J. (967)
Sinclair - Koppers Company, Inc., Port Reading, N. J. (968)
U. S. Metals Refining Co., Carteret, N. J. (969)
Phelps Dodge Copper Products Corp., Elizabeth, N. J. (970)

Procter and Gamble Manufacturing Co., Port Ivory, S. I., N. Y. (971)

Nassau Smelting and Refining Co., Inc., Tottenville, S. I., N. Y. (997)

Partial Treatment

Humble Oil and Refining Co., Linden, N. J. (972)

Chevron Oil Co., Perth Amboy, N. J. (973)

Hess Oil and Chemical Co., Port Reading, N. J. (974)

Citgo Oil Co., Linden, N. J. (975)

E. I. DuPont de Nemours and Co., Grasselli, Linden, N. J. (976)

American Cyanamid Co., Woodbridge, N. J. (977)

General Aniline and Film Corp., Linden, N. J. (978)

American Smelting and Refining Co., Perth Amboy, N. J. (979)

Public Service Generating Station, Sewaren, N. J. (980)

Public Service Generating Station, Linden, N. J. (981)

Consolidated Edison Arthur Kill Generating Station, S. I., N. Y. (982)

General American Transportation Corp., Carteret, N. J. (983)

Archer Daniels Midland Co., Elizabeth, N. J. (984)

Koppers Company, Inc., Forest Products Division, Port Reading, N. J. (985)

These industries, exclusive of the power generating stations, discharge a total of 300 MGD of wastes, imposing daily loadings of 100,000 pounds of BOD, 187,000 pounds of COD, 10 tons of oil and 5 tons of phenol. The three power stations use a total of 1,660 MGD of Arthur Kill water for cooling purposes and discharge daily 200 billion BTU's of heat.

Total Loadings

On a BOD basis, municipal and industrial wastes discharged are equivalent to the untreated sewage from more than 1.4 million persons. The total loadings amount to more than 240,000 lbs/day of BOD and more than 440 MGD of wastes. Since chlorination is not required at most of these facilities, the discharge of human wastes without disinfection represents a large bacteriological contamination of the waters.

RARITAN RIVER

Municipal

The waters downstream of its juncture with the Millstone receive the discharge of treated municipal wastes from 20,000 persons. These sources, shown in Figure 4, are as follows:

RARITAN BAY PROJECT
WASTE SOURCE LOCATIONS
RARITAN RIVER

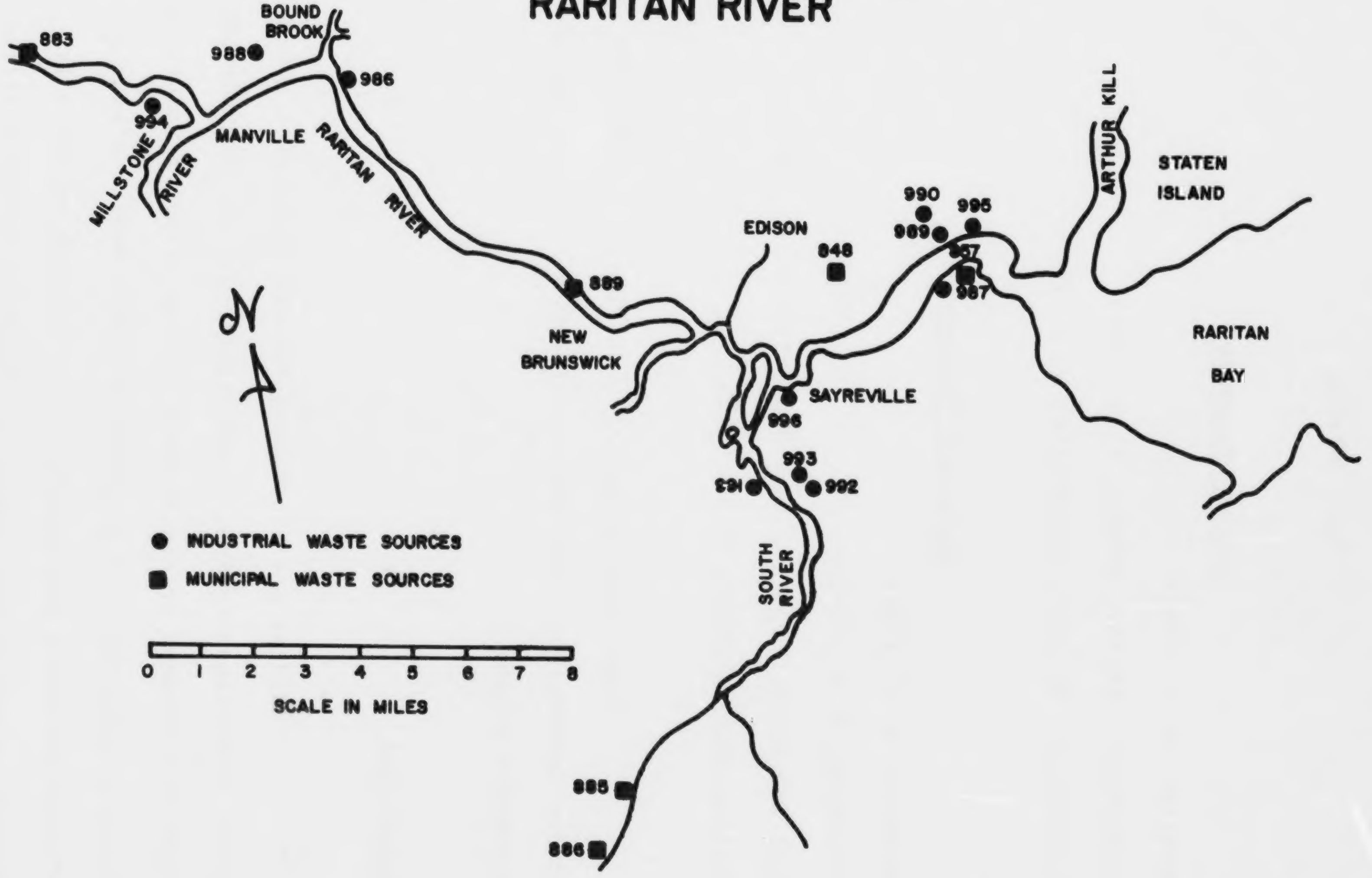
883
BOUND BROOK
988
986
994
MANVILLE
MILLSTONE RIVER
RARITAN RIVER
889
NEW BRUNSWICK
EDISON
848
990
989
995
987
ARTHUR KILL
STATEN ISLAND
RARITAN BAY
SAYREVILLE
996
993
991
992
SOUTH RIVER
885
886
N
● INDUSTRIAL WASTE SOURCES
■ MUNICIPAL WASTE SOURCES
0 1 2 3 4 5 6 7 8
SCALE IN MILES

FIGURE 4

GPO 955-949

Primary Treatment

Manville, N. J. (883)

Woodbridge - Keasby, Keasby, N. J. (845)

Sayreville - Melrose, Sayreville, N. J. (857)

Secondary Treatment

Helmetta, N. J. (885)

Jamesburg, N. J. (886)

East Brunswick Turnpike, East Brunswick, N. J. (888)

Raritan Depot, Edison, N. J. (848)

These sources amount to a flow of 2.0 MGD and impose loadings of 1,600 lbs/day of BOD and 800 lbs/day of suspended solids.

Industrial

Wastes are discharged from 10 industries and one power generating station. (See Figure 4). All provide some form of treatment or discharge a portion of their wastes to municipal systems. In a number of cases, wastes discharged without treatment are reported to be cooling waters only; however, analyses have shown contamination of these effluents.

Partial Treatment

Union Carbide Corp., Bound Brook, N. J. (986)

National Lead Co., South Amboy, N. J. (987)

American Cyanamid Co., Bound Brook, N. J. (988)

Hatco Chemical Division, W. R. Grace and Co., Fords, N. J. (989)

Tenneco Chemicals, Inc., Heyden Division, Fords, N. J. (990)

E. I. DuPont de Nemours and Co., Photo Products, Parlin, N. J. (991)

E. I. DuPont de Nemours and Co., Finishes Plant, Parlin, N. J. (992)

Hercules Powder Co., Sayreville, N. J. (993)

Johns-Manville Products Corp., Manville, N. J. (994)

Philip Carey Manufacturing Co., Perth Amboy, N. J. (995)

Jersey Central Power and Light Co., Sayreville, N. J. (996)

These processing industries discharge more than 76 MGD of wastes, and impose loadings of nearly 70,000 lbs/day of BOD and more than 45,000 lbs/day of suspended solids. The power generating station returns 300 MGD of cooling water to the river, with a heat discharge of 250 billion BTU's.

Federal Installations

The only installation discharging is Camp Kilmer

(889). Presently the site of a Job Corps Training Center operated for the Office of Economic Opportunity, it provides secondary treatment for wastes from 1,000 people. Flow averages 1.0 MGD and has a BOD loading of 25 lbs/day.

Total Loadings

On a BOD basis, municipal and industrial wastes discharged to the Raritan River are equivalent to the untreated sewage from 430,000 persons. Loadings from the 88 MGD flow amount to 71,000 lbs/day of BOD and 800 lbs/day of suspended solids. On both a flow and BOD basis, industry contributes 98 percent of the wastes discharged.

UPPER BAY

Municipal

The waters receive untreated wastes from an estimated 1.6 million persons, and treated wastes from 2.2 million persons. Sources are as follows:

No Treatment

Manhattan, N. Y.

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Red Hook, Brooklyn, N. Y.

Staten Island (St. George, Stapleton and West New Brighton), N. Y.

Primary Treatment

Bayonne, N. J. (890)

Jersey City East, N. J. (891)

Passaic Valley Sewer Commission, N. J. (892)

Port Richmond, Staten Island, N. Y. (893)

Intermediate Treatment

Owl's Head, Brooklyn, N. Y. (894)

Wastes from these raw and treated sources total more than 900 MGD and impose a loading of more than 800,000 lbs/day of BOD and 640,000 lbs/day of suspended solids. Wastes from the treated sources are not disinfected prior to discharge.

Federal Installations

Installations discharging are as follows:

U. S. Public Health Service Hospital, Staten Island, N. Y. (895)

U. S. Public Health Service Quarantine Station, Staten Island, N. Y. (896)

Fort Hamilton, Brooklyn, N. Y. (897)

Major portion of these wastes are discharged to New York City's sewer system.

AREA-WIDE DISCHARGES

Boating

Waters of the study area receive wastes from commercial vessels and recreational boats. Pollution from commercial vessels, generally concentrated in berthing areas, was estimated equivalent to 600 persons. It is estimated that recreational boats contribute 725 lbs/day of BOD and a bacterial loading equivalent to the raw discharge from nearly 6,000 persons.

Combined Sewers

Combined sewer systems with stormwater overflows which discharge into Raritan Bay or immediately adjacent waters include those of Perth Amboy, N. J.; Tottenville, Staten Island, N. Y.; northeasterly Staten Island, N. Y.;

and the Red Hook section of Brooklyn, N. Y.

Overflow from the Perth Amboy system during a summer storm was estimated at 22 MGD, with a BOD loading at 7,000 lbs/day. Contamination by bacteria as a result of such overflows constitutes a health hazard to users of these waters.

No estimates were made for other systems, as they presently discharge raw sewage under dry weather conditions. Until such time as raw sewage discharges are abated, no measurements can be made of the effect of such overflows since they cannot be distinguished from normal dry weather discharges.

EFFECTS ON WATER QUALITY

Raritan Bay

Discharge of wastes to Raritan Bay results in a degradation of water quality. Movement of municipal wastes from Upper Bay through the Narrows results in bacteria densities on the bathing areas of Staten Island, New York, in excess of the established limits for bathing. *Salmonella* organisms were isolated from swimming areas on Staten Island. The presence of pathogenic bacteria directly implies a health hazard and attests to the degraded water quality.

Shellfish taken from the bay indicated high bacterial counts and the presence of Salmonella organisms. Hence, a health hazard exists when these shellfish are consumed raw or inadequately cooked. Virtually all of the productive shellfish harvest areas in the study waters have been closed by action of the States of New York and New Jersey. The discharge of industrial wastes results in tainting of shellfish meats by phenols and mineral oils, so as to render them unsuitable for market.

Arthur Kill

As a result of the discharges previously described, water quality in the Arthur Kill is degraded. The imposed oxygen demand exceeds the assimilative capacity of the tidal strait so that dissolved oxygen was absent. In the reach from the Elizabeth River to Newark Bay dissolved oxygen was often zero. At some stations the kill was found to be devoid of benthic organisms due to the absence of adequate dissolved oxygen levels, together with the presence of oil deposits and toxic materials which created an environment unsuitable for aquatic life.

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Raritan River

As a result of waste discharges these waters undergo extreme degradation. At times, in the upper reaches, dissolved oxygen was zero, resulting in septic conditions and the formation of objectionable gases. In the past the waterway was used for bathing and fishing; however, loads now imposed prevent its utilization for recreational purposes. In addition, these wastes are transported into the western end of Raritan Bay, acting as an additional source of pollution to that water.

POLLUTION ABATEMENT PROGRESS

Abatement Orders

The New Jersey State Department of Health has issued formal abatement orders against the following sources of pollution, requiring them to cease and desist pollution and come forward with plans for abatement:

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Source	Date Ordered	Required Compliance Date
Hatco Chemical Div., W. R. Grace and Co.	Dec. 21, 1962	Apr. 15, 1963
Union Carbide Corps.	July 14, 1942	None
Stabilized Pigments	Dec. 21, 1962	Apr. 15, 1963
General Aniline and Film Corp.	Jan. 22, 1963	Jan. 27, 1964
American Cyanamid Co., Linden	Jan. 22, 1963	Jan. 27, 1964
Reichhold Chemicals, Inc., Elizabeth	Jan. 23, 1963	Jan. 7, 1965
Humble Oil and Refining Co.	Jan. 22, 1963	Jan. 27, 1964
Philip Carey Manufacturing Co.	Sept. 1, 1961	Dec. 1, 1961
Hess Oil and Chemical Co.	Aug. 26, 1964	Dec. 15, 1964
Borough of Highlands	Dec. 11, 1964	April 1, 1965
Linden-Roselle Sewerage Dist.	Jan. 22, 1963	Jan. 27, 1964
Woodbridge-Sewaren	Jan. 22, 1963	Jan. 27, 1964
Rahway Valley Sewerage Auth.	Jan. 22, 1963	Jan. 27, 1964
Joint Meeting	-	-
Carteret	Consent judgment to be issued	

According to the Department of Health, by early March 1967 the following corrective measures had been taken:

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Source	Action
Hatco Chemical Div., W. R. Grace and Co.	Connected to Middlesex County Sewerage Authority, Nov. 1966
Union Carbide Corp.	With exception of cooling water, connected to Middlesex County Sewerage Authority
Reichhold Chemicals, Inc.	Connected to municipal sewer, January 1966
Humble Oil and Refining Co.	Treatment facilities constructed for several areas of plant

In early 1966, the New Jersey Department of Health classified the waters of Raritan Bay and Raritan River and issued orders requiring construction of secondary treatment facilities as follows:

Agency	Date Issued	Compliance Date
American Cyanamid Co., Bound Brook	2-18-1966	6-1-1966
Johns Manville Products Corp.	2-18-1966	6-1-1966
Middlesex County Sewerage Auth.	2-18-1966	6-1-1966
Borough of Manville	2-18-1966	6-1-1966
Perth Amboy	2-18-1966	6-1-1966
Borough of Sayreville	2-18-1966	6-1-1966
South Amboy	2-18-1966	6-1-1966
Woodbridge Township	2-18-1966	6-1-1966

Agency	Date Issued	Compliance Date
Madison Township Sewerage Auth.	4-7-1966	8-15-1966
Borough of Keyport	4-7-1966	8-15-1966
Borough of Keansburg	4-7-1966	8-15-1966
Borough of Atlantic Highlands	4-7-1966	8-15-1966
Borough of Matawan	4-7-1966	8-15-1966
Matawan Twp. Mun. Ut. Authority (2 plants)	4-7-1966	8-15-1966

According to the Health Department, as of early 1967 virtually all of the above were making satisfactory progress, either in developing plans to upgrade existing facilities or in conducting studies to develop regional sewerage authorities or facilities. To date, these orders have not met compliance.

The New York City Department of Health has issued orders against the following pollution sources in Staten Island:

	Date Ordered	Compliance Date	Remarks
Mount Loretto Home	March 27, 1962	April 1964	Complied
St. Josephs by the Sea	March 27, 1962		Complied
Richmond Memorial Hospital	March 15, 1962	Sept. 1964	Complied
Nassau Smelting and Refining Co., Inc.	March 27, 1962	May 1969	To connect to city sewer by May 1969
Procter and Gamble Manufacturing Co.	April 5, 1963	June 1968	To connect to city sewer by June 1968
S. S. White Co.	March 15, 1962	April 1969	To connect to city sewer by April 1969

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In the case of the last three sources listed, the compliance date is based upon completion of new interceptor sewers and/or construction of treatment facilities by the city to handle these wastes.

The Interstate Sanitation Commission has one abatement order outstanding against the City of Elizabeth, New Jersey, requiring construction of interceptor sewers to eliminate the raw discharge now emanating from the Bayway and Singer areas. Plans are now under way for such construction.

Construction and Planning Programs (1962 to date)

Construction Completed

New treatment facilities have been constructed, or existing facilities enlarged at the following:

Keyport, N. J.
Keansburg, N. J.
Madison Township, N. J.
Newton Creek, N. Y.
Middlesex County Sewerage Authority, N. J.

Construction Plans Under Way or Complete

Madison Township, N. J. (Secondary)

Port Richmond, N. Y. (Interceptors)

Oakwood Beach, N. Y. (Expansion and Interceptors)

Elizabeth, N. J. (Interceptors)

Preliminary Planning Under Way or Complete

Highlands, N. J.

Woodbridge-Sewaren, N. J.

Atlantic Highlands, N. J.

Red Hook, N. Y.

Monmouth County, N. J.

Keyport, N. J.

Keansburg, N. J.

Tottenville, N. Y.

Fresh Kills, N. Y.

Pilot Plant Studies Under Way or Complete

The following have undertaken pilot plant studies to determine methods for providing increased treatment:

Middlesex County Sewerage Authority, N. J.

Linden-Roselle Sewerage District, N. J.

Rahway Valley Sewerage Authority, N. J.

Joint Meeting, N. J.

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Classification - Treatment Requirements

Waters under the jurisdiction of the Interstate Sanitation Commission and the State of New York Water Resources Commission have been classified. In 1964, the New Jersey State Department of Health adopted rules and regulations for classification of waters in its jurisdiction. The Department classified the waters of Raritan Bay and tidal portions of the Raritan River in 1965, and in 1966 issued a proposed classification for the Arthur Kill.

In 1962, the Interstate Sanitation Commission issued requirements for secondary treatment of domestic and industrial wastes discharged to the Arthur Kill. These criteria called for at least an overall BOD reduction of 80 percent.

Both the States of New York and New Jersey have issued requirements for seasonal chlorination, effective in 1967, of all wastes discharged within the area of the Interstate Sanitation Commission.

In 1965, under the Federal Water Pollution Control Act, the Secretary of Health, Education, and Welfare convened a conference on pollution of the Hudson River and its tributaries, including Upper Bay. The conferees recommended secondary treatment and effective disinfection of all wastes discharged to these waters, and established a timetable calling for completion by January 1970.

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REPORT
for
THE CONFERENCE ON POLLUTION
RARITAN BAY AND ADJACENT
INTERSTATE WATERS

THIRD SESSION

VOLUME II-SOURCES OF POLLUTION

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHEAST REGION - RARITAN BAY PROJECT
METUCHEN, N.J.
MAY 1967

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SOURCES OF POLLUTION

MUNICIPAL - INSTITUTIONAL

SOURCES OF POLLUTION

General

Major pollutional loads to the study waters are presented in Table I. Examination of these data indicates the large demand placed upon the assimilative capacity of these waters by the discharge of treated and untreated municipal and industrial wastes. Raritan Bay and Arthur Kill receive directly more than 480 MGD of wastes from a tributary population exceeding 1.3 million people. These discharges represent a BOD loading of 430,000 lbs/day.

The discharge of additional wastes in adjacent waters increases the magnitude and impact of the direct loads. When discharges to Upper Bay and Raritan River are included the total wastes volume approaches 1,500 MGD, which represents a BOD loading of greater than 1,300,000 lbs/day from a population exceeding 5.0 million people.

Contamination by pollutants other than BOD from these same sources is also a significant problem. Bacteriological pollution results from the discharge of more than 900 MGD of unchlorinated and raw municipal wastes emanating from a tributary population of 3.8 million persons. Such pollution constitutes a definite hazard to the health of persons having contact with these waters.

Nearly 75% of the total wastes volume is from industry. This results in pollution of study waters by a variety of contaminants in addition to oxygen consuming material. Pollutants such as oil, phenol, phosphate and nitrogen result in unsightly conditions, destruction of desirable aquatic life, tainting of fish and shellfish and eutrophication of the water.

Additional pollution results from the discharge of more than 1.0 billion gallons per day of "hot" cooling water from power generating plants adjacent to these waters.

Further contamination occurs in localized areas due to the discharge of wastes from recreational and commercial vessels. The overflow of sewage from combined storm-sanitary sewer systems also represents an important factor in pollution of these waters.

MUNICIPAL AND INSTITUTIONAL WASTES

General

Treated and raw municipal and institutional wastes discharged to Raritan Bay, Arthur Kill, Raritan River, and that portion of Upper Bay to close proximity to the Narrows, are summarized in Table II.

Raritan Bay receives the direct discharge of treated and untreated wastes from more than 511,000 persons. A total of 20 wastewater treatment plants, serving 508,000 people, discharge 182,000 lbs/day of BOD and 40.000 lbs/day of suspended solids. On a population basis, more than 99% of the domestic wastes discharged receives treatment of some form. The only major source of raw municipal wastes is the Tottenville area of Staten Island, N. Y., with an estimated population of 3,000 people.

Treated municipal wastes from nearly 830,000

TABLE I

MUNICIPAL AND INDUSTRIAL WASTE LOADINGS[1]

Type Source	Flow MGD	Loadings (lbs/day)		Tributary Population	Population Equivalent (BOD) Discharged
		BOD	Suspended Solids		
		DISCHARGES TO RARITAN BAY			
Municipal	72.1	182,500	40,560	507,800	1,069,200
Industrial	0.1 [2]	2,500			14,700
Total	72.2 [2]	185,000			1,083,900
		DISCHARGES TO ARTHUR KILL			
Municipal	81.8	138,360	55,350	831,000	812,750
Industrial	367.3 [2]	104,640			615,000
Total	449.1 [2]	243,000			1,427,750
		DISCHARGES TO RARITAN RIVER			
Municipal	2.0	1,605	845	20,365	9,430
Industrial	85.7 [2]	70,100			421,000
Total	87.7 [2]	71,707			430,430
		TOTAL DISCHARGES TO STUDY AREA			
Municipal	155.9	322,465	96,755	1,359,165	1,891,380
Industrial	453.1	177,240			1,050,700
Total	609.0	499,705			2,942,080
		DISCHARGES TO UPPER BAY			
Municipal	915.9	808,510	645,100	3,815,100	4,758,400
Industrial	N.D. [3]	N.D.	N.D.	N.D.	N.D.
Total	915.9	808,510	645,100	3,815,100	4,758,400

NOTES:
1. Does not include additional wastes loadings from recreational and commercial vessels, or from stormwater overflow.
2. Excludes flow from power generating industry.
3. No data available.

persons, representing a BOD load of 137,000 lbs/day and 54,000 lbs/day of suspended solids are discharged directly to the Arthur Kill. There is no significant discharge of untreated municipal of institutional wastes to the Kill, although some raw discharges do exist, notably in the City of Elizabeth, N.J.

That portion of the Raritan River within the Project study area receives treated wastes from 20,400 people. The seven wastewater treatment plants discharging to the waterway and its tributaries contribute a load of 1,600 lbs/day of BOD and 800 lbs/day of suspended solids.

Wastes discharged to Upper Bay have been included in Table II since the transfer of pollutants through the Narrows has a significant effect on the easterly portion of Raritan Bay. Upper Bay receives wastes from more than 3.8 million people, of which, that from 1.6 million is discharged without treatment. Five wastewater treatment plants account for 343 of the 915 MGD discharged. Raw wastes amounting to 572 MGD are discharged from Manhattan, Red Hook Section of Brooklyn and easterly Staten Island. The total load is estimated at 808,000 lbs/day of BOD and 645,000 lbs/day of suspended solids. It is important to note that all of the municipal plants do not practice chlorination.

Sources

Known sources of municipal and institutional wastes discharged to study area waters are presented in Table III. These data are based on Project sampling programs or information provided by the Interstate Sanitation Commission and the New Jersey State Department of Health.

Major municipal wastewater treatment plants discharging to Raritan Bay and Arthur Kill were sampled at periodic intervals by the Project. The sampling program included 24-hour studies, which related influent and effluent so as to provide an indication of treatment efficiency; and weekly samples -- collected to provide a measure of the variation in wastes loads. Since September 1963 the Project has conducted a surveillance program consisting of visual inspections and periodic sampling to provide information on major changes in plant operation.

Table IV presents the results of Project studies of the major municipal wastewater treatment plants discharging to Raritan Bay and Arthur Kill. Plant operating personnel, records and laboratory control procedures were observed and compared with the minimum recommendations of the Conference of State Sanitary Engineers. Particular attention was directed to bacteriological effluent quality and suspended solids removal. This permitted a comparison of Project data with the standards of the Interstate Sanitation Commission, which has jurisdiction over all wastes discharged to the study waters.

Information collected indicates that although the treatment facilities were generally able to meet bacteriological requirements, certain of the older plants were unable to maintain satisfactory solids removal efficiencies. A number of plants were staffed with improperly trained operators. In all but seven of the facilities, laboratory control procedures did not meet the minimum standards recommended by the Conference of State Sanitary Engineers.

Technical information, along with a history and description of each of the treatment facilities discharging to the study area waters is included in this section.

TABLE II

SUMMARY OF MUNICIPAL AND INSTITUTIONAL WASTES

	TREATED WASTE						UNTREATED WASTE					TOTAL				
RECEIVING WATER AND ORIGIN	NO. PLANTS	POPULATION SERVED	FLOW MGD	LOADINGS lbs/day		POP. EQUIV. (BOD)	POPULATION	FLOW MGD	LOADINGS lbs/day		POP. EQUIV. (BOD)	POPULATION	FLOW MGD	LOADINGS lbs/day		POP. EQUIV. (BOD)
				BOD	SUSP. SOLIDS				BOD	SUSP. SOLIDS				BOD	SUSP. SOLIDS	
Raritan Bay N.J.	13	415,175	60.6	178,430	36,760	1,045,250	0	0	0	0	0	415,175	60.6	178,430	36,760	1,045,250
N.Y.	7	89,625	11.2	3,560	3,140	20,950	3,000	0.3	510	660	3,000	92,625	11.5	4,070	3,800	23,950
TOTAL	20	504,800	71.8	181,990	39,900	1,066,200	3,000	0.3	510	660	3,000	507,800	72.1	182,500	40,560	1,069,200
Arthur Kill N.J.	6	820,000	80.6	135,340	53,990	795,000	5,000	0.5	1,160	760	6,850	825,000	81.1	136,500	54,750	801,850
N.Y.	1	6,000	0.7	1,860	600	10,900	0	0	0	0	0	6,000	0.7	1,860	600	10,900
TOTAL	7	826,000	81.3	137,200	54,590	805,900	5,000	0.5	1,160	760	6,850	831,000	81.8	138,360	55,350	812,750
ALL Raritan River NJ	7	20,365	2.0	1,605	845	9,430	0	0	0	0	0	20,365	2.0	1,605	845	9,430
Upper Harbor N.J.	3	1,405,100	238.4	436,970	255,820	2,572,200	0	0	0	0	0	1,405,100	238.4	436,970	255,820	2,572,200
N.Y.	2	810,000	104.5	99,540	37,280	586,200	1,600,000	573.0	272,000	352,000	1,600,000	2,410,000	677.5	371,540	389,280	2,186,200
TOTAL	5	2,215,100	342.9	536,510	293,100	3,158,400	1,600,000	573.0	272,000	352,000	1,600,000	3,815,100	915.9	808,510	645,100	4,758,400

TABLE III

MUNICIPAL AND INSTITUTIONAL WASTES SOURCES 1/

Source	State	Treatment	Year Built/ Altered	Population Served	Flow, MGD		Loadings, lbs/day		Pop. Equiv. (BOD) 2/
					De-sign	Ave Daily	BOD	Suspended Solids	
RARITAN BAY									
Highlands	N.J.	Primary	1929	4,200	1.7	0.8	660	550	3,880
Atlantic Highlands	N.J.	Primary	1929	4,200	0.6	0.6	650	410	3,820
Leonardo Naval Depot	N.J.	Intermediate	1949	75	-	0.02	Small	Small	Small
Keansburg	N.J.	Primary	1950/1963	7,500	3.2	2.9	990	1,160	5,820
Keyport	N.J.	Primary	1929/1962	7,000	1.0	1.0	670	440	3,940
Matawan Boro 3/	N.J.	Primary	1923/1962	3,600	0.8	0.4	430	320	2,520
Matawan Twp.	N.J.	Secondary	1953	1,000	-	0.08	Small	Small	Small
Madison Twp.	N.J.	Primary	1963	3,500	1.2	0.5	430	220	2,520
Sayreville - Morgan 3/	N.J.	Primary	1952	2,000	0.3	0.2	240	180	1,400
South Amboy	N.J.	Primary	1939	8,400	1.0	0.9	790	340	4,650
Middlesex County 4/	N.J.	Primary	1959/1965	330,900	52.0	46.8	165,450	30,200	974,000
Perth Amboy	N.J.	Primary	1934	38,000	10.0	6.2	8,120	2,940	42,700
Junior High School #7 5/	N.Y.	Secondary	1965	2,100	0.02	-	INSIGNIFICANT	INSIGNIFICANT	INSIGNIFICANT
Mt. Loretto Home #1 5/	N.Y.	Septic Tank +Cl_2	1963	415	-	0.04			
Mt. Loretto Home #2 5/	N.Y.	Septic Tank +Cl_2	1963	760	-	0.08			
Richmond Mem. Hospital 5/	N.Y.	Septic Tank +Cl_2	1936/1954	360	-	0.04			
Daytop Lodge	N.Y.	Septic Tank	-	80	-	-			
Matawan Twsp #3	N.J.	Secondary	1966	4,800	0.7	0.2	-	-	-

TABLE III (Cont'd)

MUNICIPAL AND INSTITUTIONAL WASTE SOURCES 1/

Source	State	Treatment	Year Built/ Altered	Population Served	Flow, MGD		Loadings, lbs/day		Pop. Equiv. (BOD) 2/
					De-sign	Ave Daily	BOD	Suspended Solids	
RARITAN BAY (Cont'd)									
St. Joseph's School 5/	N.Y.	Intermediate	1964	910	0.02	-	Small	Small	Small
Oakwood Beach	N.Y.	Secondary	1956	85,000	15.0	11.0	3,560	3,140	20,950
Tottenville 3/ 5/	N.Y.	None	-	3,000	-	0.3	510	660	3,000
ARTHUR KILL									
Woodbridge-Sewaren	N.J.	Primary	1954	30,000	10.0	3.9	4,350	2,700	25,600
Carteret	N.J.	Primary	1953	15,000	3.0	2.5	2,790	1,670	16,400
Rahway Valley	N.J.	Primary	1927	180,000	16.7	19.7	30,200	12,950	177,500
Linden-Roselle	N.J.	Primary	1952	120,000	12.5	7.9	22,000	7,170	129,500
Joint Meeting 6/	N.J.	Primary	1937	475,000	100.0	46.6	76,000	29,500	446,000
Elizabeth 7/	N.J.	None	-	Unknown	-	0.5	1,160	760	6,850
Willowbrook State School 8/	N.Y.	Primary	1941	6,000	0.6	0.7	1,860	600	10,900
RARITAN RIVER									
Helmetta 9/	N.J.	Secondary	-	665	-	0.03	Small	Small	Small
Jamesburg 9/	N.J.	Secondary	-	1,500	-	0.35	210	60	1,230
Manville 9/	N.J.	Primary	-	8,600	-	1.0	620	250	3,650
Woodbridge-Keasby 9/	N.J.	Primary	-	8,000	-	0.5	655	445	3,850

TABLE III (Cont'd)

MUNICIPAL AND INSTITUTIONAL WASTES SOURCES 1/

Source	State	Treatment	Year Built/ Altered	Population Served	Flow, MGD		Loadings, lbs/day		Pop. Equiv. (BOD) 2/
					Design	Ave Daily	BOD	Suspended Solids	
RARITAN RIVER (Cont'd)									
E. Brunswick Turnpike 9/	N.J.	Secondary	-	500	-	0.01	Small	Small	Small
Sayreville-Melrose 10/	N.J.	Primary	1949	1,000	0.1	0.03	120	90	700
Raritan Depot	N.J.	Secondary	1917	100	-	0.06	Small	Small	Small
UPPER NEW YORK HARBOR									
Bayonne 8/	N.J.	Primary	1954	75,000	20.0	6.7	9,230	4,600	54,200
Jersey City East 8/	N.J.	Primary	1957	180,100	46.6	31.7	40,540	20,820	238,000
Passaic Valley 8/ 11/	N.J.	Primary	1937	1,150,000	-	200.0	387,200	230,400	2,280,000
Owl's Head 8/	N.Y.	Intermediate	1952	750,000	160.0	97.8	90,660	33,250	534,000
Port Richmond 8/	N.Y.	Primary	1953	60,000	10.0	6.7	8,880	4,030	52,200
Manhattan 3/ 5/ 12/	N.Y.	None	-	1,000,000	-	500.0	170,000	220,000	1,000,000
Brooklyn -Red Hook 3/ 5/	N.Y.	None	-	500,000	-	60.0	85,000	110,000	500,000
Staten Island East 3/ 5/ 13/	N.Y.	None	-	100,000	-	13.0	17,000	22,000	100,000

NOTES:

1. Unless otherwise noted, data are based on results of Project studies.

2. Calculated from BOD loading, using 1 PE = 0.17 lbs/day BOD.

3. Loads calculated on basis of 0.17 lbs per capita per day BOD and 0.22 lbs per capita per day suspended solids in raw sewage, with following treatment removed efficiencies:

Primary:	BOD 30%	Suspended solids 60%
Secondary:	BOD 85%	Suspended solids 95%

4. Population served from ISC; Loadings and flow based on Project studies.

5. Population and flows estimated.

6. Population is 1950 tributary population.

7. Population served unknown. Flow data from ISC indicates 300,000 gpd from Bayway area; 200,000 gpd from Singer area. Loadings calculated using data for Elizabeth Joint Meeting, removals as given in Note 3, and prorating on basis of ratio of flows.

8. Data from ISC.

9. Data from New Jersey State Department of Health.

10. Flow and population from ISC. Loads calculated per Note 3.

11. In 1965, outfall line was broken. Plant now discharges to Newark Bay.

12. Population increases to estimated 3.5 million during working day.

13. Includes St. George, Stapleton and West Brighton, Staten Island, N. Y.

TABLE IV

SUMMARY OF OPERATIONS AND MAINTENANCE OF MAJOR MUNICIPAL TREATMENT PLANTS

PLANT	CHLORINE REQD.^{4}	REQ. %^{4} REM. SUS. SOLIDS	24-HOUR STUDIES			GRAB SAMPLE COLIFORM		SATISFACTORY	OPERATION^5	
			No.	No. Mtg. Bact.	No. Mtg. S. S.	No.	No. >1.0/ML	PERSONNEL	LAB CONTROL	RECORDS
Oakwood Beach	Yes	60	4	4	3^1	68	22	Yes	Yes	Yes
Joint Meeting	No	10	1	-	1	11	-	Yes	Yes	Yes
Linden-Roselle	No	10	1	-	1	11	-	Yes	Yes	Yes
Rahway Valley	No	10	1	-	1	11	-	Yes	Yes	Yes
Carteret	Yes	10	1	0	1	11	5	Yes	No	Yes
Sewaren	Yes	10	1	1	1	11	6	Yes	No	Yes
Perth Amboy	Yes	60	5	4	2^1	65	35	No	No	No
Keasby	Yes	60	1	1	0	19	2	Yes	Yes	Yes
Raritan Depot	Yes	60	-	-	-	18	1	Yes	No	Yes
Middlesex County	Yes	60	4	3	4	68	23	Yes	Yes	Yes
Sayreville-Melrose	Yes	60	-	-	-	20^2	1	-	-	-
South Amboy	Yes	60	4	4	3^1	66	8	Yes	No	Yes
Sayreville-Morgan	Yes	60	1^3	1	1	19	3	Yes	No	Yes
Madison Township (Knollcroft)	Yes	60	3	3	2	22	2	Yes	No	Yes
Matawan Boro.	Yes	60	1	1	0	22	4	Yes	No	Yes
Matawan Township	Yes	60	-	-	-	18	3	Yes	No	Yes
Matawan Township #3	Yes	60	-	-	-	1	0	Yes	Yes	Yes
Keyport	Yes	60	4	4	2	63	13	No	No	Yes
Keansburg	Yes	60	3	2	0	59	30	Yes	No	Yes
Leonardo	Yes	60	1^3	1	1	19	2	Yes	No	Yes
Atlantic Highlands	Yes	60	4	1	1	69	4	No	No	No
Highlands	Yes	60	4	3	1	69	16	Yes	No	No

KEY

1 - Only 3 studies with solids data

2 - ISC data

3 - 8-hour study

4 - Requirements for effluent quality established by ISC classification of receiving water

5 - Satisfactory as compared with "Recommendations for Minimum Personnel and Laboratory Control" Conference of State Sanitary Engineers

HIGHLANDS

Background

The Highlands, N.J. plant, owned and operated by the Borough was constructed in 1928-29 to serve a population of approximately 15,000 people. Presently, the plant serves [illegible] summer peak of [illegible] persons. The design flow is reported to be 1.7 MGD.

The existing plant, which has never undergone expansion of any type, provides primary treatment for domestic and commercial wastes developed within the community.

The separate sewer system, constructed more than three and one half decades ago, is provided with two pumping stations -- Waterwich Avenue and South Bay Avenue. Reportedly, these stations cannot be bypassed. The quantity of flow handled by these two facilities, in relation to the total sewage flow, is not known since accurate flow records are not available at the treatment plant nor at the lift stations. The area served by the sewer system includes the Borough of Highlands and the Monmouth Hills Development.

Treatment

The plant consists of a bar screen, four single story settling (septic) tanks, chlorine contact chamber and glass covered sludge drying beds. The plant's 16-inch diameter outfall line was designed to traverse the Shrewsbury River and Sandy Hook and discharge into the Atlantic Ocean. This line was broken in the early 1950's, and effluent presently discharges into the Shrewsbury approximately 300 feet south of Buoy 13. This break was verified with dye by Project personnel on October 11, 1962. There is no known bypass at the treatment plant. However, during severe rain storms the settling tanks flood, with the overflow discharging into Sandy Hook Bay via street gutters.

Findings

According to ISC records, there has been no method of accurately determining flow at this installation for at least the past eight years. To measure the flow, the Raritan Bay Project on July 28-29, 1964, conducted a 24-hour comprehensive flow study. Results of this investigation indicated that the plant's average flow approximates 0.85 MGD, and the maximum 1.4 MGD. This hydraulic study indicated that infiltration is a major problem. It is estimated that the background level for seepage is 0.4 MGD.

Presently, under normal conditions, two of the single story settling tanks are operated in parallel, while the remaining two units are cleaned and drained. Operation of the tanks are alternated approximately every six months. Based on an average flow of 0.85 MGD the detention time is 3.9 hours, which is below that required as a minimum by the New Jersey State Health Department design regulations. According to these rules the capacity of single story settling tanks, without sludge digestion, "shall be at least eight hours based on design flow." If detention time is calculated on the actual 1.7 MGD design flow, the holding capacity of the tanks would be approximately two hours.

Performance Summary

Date	Flow*	Sus Solids		BOD		Coliform %
	mgd	Eff mg/1	%Rem	Eff mg/1	%Rem	over 1.0/ml
24 hour studies						
8-9, 10-62	0.85	141	42	142	-	70
10-4, 5-62	0.85	84	35	70	42	33
12-6, 7-62	0.85	48	38	62	76	25
8-22,23-63	0.85	46	64	103	3	37
Grab samples						
8-7-62 to 9-11-63 (50 samples)	0.85	59	-	112	-	24
10-6-64 to 12-21-65 (14 samples)	0.85	61		75	-	21
1-18-66 to 5-18-66 (5 samples)	0.85	72		72	-	20

*Based on hydraulic study 7-28, 29-64

During three of the four 24-hour studies conducted, the effluent failed to meet ISC requirements for solids removal. Bacteriologically, the plant failed to meet the coliform requirements during one of the day-long studies. From data obtained, it is evident that chlorination is relied upon heavily to provide a reasonable degree of treatment. Control of the application of chlorine at this point is poor, as there is no continual residual chlorine indicator tied into the feed rate. As a result, the dosage applied in many instances is inadequate during high flow periods. For example: During the 24-hour study of October 4-5, 1962, the coliform counts during the morning high flow periods ranged from 170 to 16,000 organisms per 100 ml.

Laboratory control procedures at Highlands do not meet the minimum requirements of the Conference of State Sanitary Engineers, which recommend daily tests for settleable solids and chlorine residual; and occasionally pH of the raw wastes. The only tests performed at Highlands are air and effluent temperatures and chlorine residual every two hours. No tabular record, as recommended, is kept of test results; although an operating diary-type log is maintained.

Paul DeFalco

ATLANTIC HIGHLANDS

Background

Atlantic Highlands, N.J., located on the southern shore of Sandy Hook Bay approximately two miles west of the Atlantic Ocean, is served by a 0.6 MGD primary treatment plant. The installation, constructed in 1929, has never been expanded or modernized.

Based on information supplied by the Borough, the present population of 4,200 people increases by approximately 100 during the summer months. The popularity of this area as a summer resort, however, suggests a weekend population considerably in excess of 4,300 persons. Based on available data, the plant is presently handling an average daily flow of 590,000 gallons, even though records indicate flows as high as 1.09 MGD. The reason for this discrepancy is that the propellar-type flow meter, located after the high tide effluent pumps, is indicating the pump discharge rate which includes both sewage flow and tidal backup.

The separate sewage collection system, built in 1894, serves approximately 80% of the Borough's population.

With the exception of one pumping station which serves approximately 100 homes, the system is gravity. No known bypasses exist in the collection system. The plant bypass, located in a manhole in the street adjacent to treatment facility, has not been used in many years, as shown by the fact that the manhole cover is sealed with several layers of asphalt paving material.

Infiltration into the system is considered to be insignificant by Borough officials. Project personnel, however, have observed flow increases during and after rain storms. No reliable estimate of the magnitude of infiltration can be made since the plant's flow measuring device is either recording inaccurately or out of order completely.

Treatment

Primary treatment of sewage is provided by four single story sedimentation (septic) tanks followed by chlorination. No preliminary treatment -- screening or grit removal -- has been provided. Sludge is dewatered on glass-covered drying beds.

Effluent discharges directly into Sandy Hook Bay at a point approximately 1,000 feet offshore. During periods of low tide, effluent flows by gravity through the outfall. During high tide, an automatic tide gate goes into operation. When the sewage in the plant backs up, due to the closed gate, float-controlled pumps in the chlorine contact tank are actuated. These pumps bypass the tide gate and provide the additional head needed to overcome the backup in the outfall line.

Findings

New Jersey State Health Department's Rules and Regulations for the Design of Sewerage Facilities (Section 11.3b) states that for single story settling tanks, without sludge digestion, the capacity, exclusive of sludge capacity, shall be such as to provide at least eight hours detention time, based on design flow. Under normal conditions at Atlantic Highlands, two of the four tanks are operated in parallel for 30 to 40 days while the remaining two tanks are being cleaned. Based on an average daily flow of 590,000 gallons the detention period is slightly more than 6.6 hours.

Performance Summary

Date	Flow mgd	Sus Solids Eff mg/1	Sus Solids %Rem	BOD Eff mg/1	BOD %Rem	Coliform % over 1.0/ml
24 hour studies						
8-23, 24-62	-	72	28	91	23	96
10-11, 12-62	0.9	95	41	84	30	17
8-15, 16-63	1.1	33	59	98	36	21
1-24, 25-63	0.9	34	60	58	44	0
Grab samples						
8-7-62 to 9-11-63 (50 samples)	-	53	-	125	-	8
10-6-64 to 12-21-65 (14 samples)	0.7	64	-	90	-	0
1-18-66 to 5-18-66 (5 samples)	0.8	60	-	56	-	0

Paul DeFalco

Results of the comprehensive day-long investigations show that the plant failed to meet, with the exception of one study which was just borderline, the ISC requirement of 60% removal of suspended solids. Bacteriologically, the installation only failed to meet the ISC coliform requirements during one of the 24-hour studies.

From data obtained, it is evident that the plant relies heavily upon chlorination to provide the final stages of treatment. The problem associated with this type of operation is that since the control of the application of chlorine is poor, dosages during certain high load or flow periods may very well be insufficient to provide the required kill. For example: During the 24-hour study in October 1962, coliform counts as high as 160,000 per 100 ml were recorded during the high flow periods - (8 a.m. to 12 noon.)

The minimum standards for laboratory control, as set by the Conference of State Sanitary Engineers, are not met by this plant. Settleable solids, which should be run daily, is performed only three times per week.

Operation of the facility is presently restricted to one operator who spends approximately two hours per day at the plant. This man also reportedly returns every hour during the period of 8 a.m. to 4 p.m., to take a chlorine residual.

The standards recommend a minimum of one full time operator and one half time laborer.

Poor records of plant operation and tests performed are maintained. The standards recommend keeping an accurate daily-type log book and a tabular record of tests performed.

LEONARDO U.S. NAVAL AMMUNITION DEPOT

Background

This 20 year old intermediate treatment plant, located on the ammunition depot at Leonardo, N.J , serves 75 people. A separate sewer system, covering an area of approximately 900,000 square feet, serves the plant.

Treatment

Treatment includes screening, sedimentation (Imhoff tank), sand filtration and pre and post-chlorination. Effluent is discharged to a storm water chamber which empties into Wierd Creek, a small tributary to Raritan Bay.

Findings

Performance Summary

Date	Flow mgd	Sus Solids Eff mg/1	Sus Solids %Rem	BOD Eff mg/1	BOD %Rem	Coliform % over 1.0/ml
24 hour study						
9-8, 9-64	.005E	7*	-	10.0	-	4
Grab samples						
10-6-64 to 12-21-65 (14 samples)	.005E	19	84	12	92	14
1-18-66 to 5-18-66 (5 samples)	.005E	10	87	24	81	0

*Based on 13 samples

Data collected by the Project indicates that the effluent meets both the suspended solids and bacteriological standards of the Compact. The plant, as presently operated, is underloaded. The dosing syphons for the sand filters trip only once every 28 to 30 hours. Correspondingly, results for BOD and suspended solids removal are high.

KEANSBURG

Background

The Borough of Keansburg, N. J., located on the southern shore of Raritan Bay approximately seven miles east of the Raritan River, provides primary treatment for its domestic and commercial wastes. The plant handles wastes from a winter tributary population of 7,500 people. During the summer months, however, the weekday population is approximately 16,000 and the weekend peaks at about 25,000 people.

The community's original treatment installation, constructed in the early 1900's, was replaced by a new 2.0 MGD facility, providing chemical treatment and chlorination, in 1949-50. However, except for a short start-up period, chemicals have never been used. In August 1963, Keansburg was awarded a $90,000 FWPCA construction grant. The installation of two new flocculation-sedimentation units identical in size and shape to the two existing facilities, chlorine contact tank, and a flash mixer was completed in 1965.

The new installation is designed for a 1970 maximum flow of 3.2 MGD; which includes an allowance of 0.7 MGD for infiltration. Presently, the average flow during the winter months is approximately 1.7 MGD. During the weekday summer periods the Project has observed the average flow to be 2.9 MGD, with peak hourly rates reaching as high as 3.1 MGD.

The present plant site is subject to flooding during heavy storm periods; therefore, emergency flood doors have been provided in the main building to protect mechanical equipment. In past years, the plant has been forced to shut down several times due to flooding conditions.

Wastes are conveyed to the treatment plant by gravity through a separate sewer system constructed in 1900. Infiltration is estimated to be 0.5 to 0.7 MGD. With the exception of the treatment plant, there are no known bypasses in the system. At the plant all flow must pass the chlorination point before discharge.

Treatment

Primary treatment consisting of screening, grit removal, sedimentation and chlorination, is provided at Keansburg. Chemical feeding equipment for adding lime and ferric chloride to the raw wastes have been provided, however, it is presently not used. Sludge is digested in a single tank and dewatered on a rotary vacuum drum-type filter. Scum which accumulates on the settling tanks is pumped to the digester. Effluent is discharged into Raritan Bay through a 24-inch diameter line which terminates approximately 2,200 feet offshore.

Findings

Performance Summary

Date	Flow mgd	Sus Solids Eff mg/1	Sus Solids %Rem	BOD Eff mg/1	BOD %Rem	Coliform % over 1.0/ml
24 hour studies						
8-30, 31-62	2.9	73	55	63	22	92
10-25, 26-62	1.7	58	24	56	28	36
1-17, 18-63	1.4	78	Neg	56	22	42
Grab Samples						
8-7-62 to 9-11-63 (47 samples)	-	62	--	85	--	58
10-14-64 to 6-24-65 (7 samples)	1.3	74	--	42	--	29
1-18-66 to 5-18-66 (5 samples)	1.3	64	--	31	--	20

Paul DeFalco

During 1962 and 1963 the Project conducted three 24-hour investigations. The plant failed to meet ISC solids removal requirements during all of these studies -- in one case a negative removal was recorded. ISC also reported finding negative removals during their investigations.

Based on Project observations it is felt that a contributing factor to the small solids removal is the uncontrolled release of supernatant from the digester, which causes overloading of the system. This condition has been noticed as recently as August 1966.

Bacteriologically, only one of the three 24-hour studies failed to meet the Compact coliform requirement. However, for the grab samples collected during '62 and '63, 27 out of 47, or approximately 58%, had a coliform count of greater than one per ml. This fact gives further proof to Project observations that treatment at this plant improves with the duration of the investigation, and that this higher degree of treatment is not duplicated in unannounced grab samples.

A review of plant operating records reveals that the plant performs the following tests: Chlorine residual -- every two hours; settleable solids -- three times per day. Laboratory control procedures carried out at Keansburg are below the minimum standards set by the Conference of State

Sanitary Engineers. The plant fails to meet the following recommendations: BOD and suspended solids of raw and final -- once per week; and pH and total solids of digested sludge -- when sludge is drawn.

KEYPORT

Background

Borough of Keyport, N.J., is located on the southern shore of Raritan Bay, approximately five miles east of the mouth of the Raritan River. The original wastewater treatment facility was constructed in 1929, and expanded in 1936 to handle a design flow of 0.4 MGD. In 1961-62 the facility underwent extensive reconstruction. This expansion program included a new grit removal device, settling tank, digester and vacuum filter. The old sedimentation tank, digester and glass-covered drying beds are now on stand-by status. The original chlorine contact tank was also rebuilt during this period.

The treatment installation serves an area of approximately one square mile, and the tributary population, exclusive of seasonal fluctuations, is estimated at 7,000 people. The summer influx is estimated at 500 to 1,000 persons. Flow from industries is considered negligible.

The sanitary sewer system is provided with three pumping stations. Only one of the installations, South Keyport, is designed for bypassing. Raw sewage discharges from this lift station would empty into Chinkarora Creek.

Treatment

Primary treatment -- pre-chlorination, screening, grit removal, sedimentation, digestion, vacuum filtration, post-chlorination -- is provided for a design flow of 1.0 MGD. The maximum design flow is 4.0 MGD. Treated sewage is discharged through a 24-inch diameter pipe extending approximately 140 feet into Raritan Bay.

Findings

A review of plant flow records for the past several years reveals that the flow is gradually approaching the design rate of 1.0 MGD. During the July 1964, 24-hour study, the average flow was 0.99 MGD. During 12 out of 24 hours, the flow rate was equal to, or exceeded the design value. If this flow increase continues in the same pattern as in past years, it is estimated that the plant might very well exceed its design capacity sometime during 1967.

Performance Summary

Date	Flow mgd	Sus Solids		BOD		Coliform % over 1.0/ml
		Eff mg/1	%Rem	Eff mg/1	%Rem	
24-hour studies						
11-1, 2-62	0.7	46	66	131	25	20
12-13, 14-62	0.8	32	65	103	34	8
1-31, 2-1-63	0.7	67	44	101	38	0
7-13, 14-64	1.0	108	46	87	38	46
Grab Samples						
8-7-62 to 9-11-63 (44 samples)	-	56	-	156	-	25
10-14-64 to 12-21-65 (14 samples)	0.9	49	-	81	-	7
12-27-65 to 5-18-66 (5 samples)	0.9	75	-	64	-	20

Paul DeFalco

It is evident that the plant, even though constructed in 1962, is not complying completely with ISC standards for solids removal. On two occasions it failed to meet the minimum 60% removal rate.

The effluent during all 24-hour studies met ISC coliform standards. It is noteworthy to point out, that although 13 out of 24 samples collected on July 13-14, 1964 had a coliform count of less than one per ml, the geometric mean for all 24 samples was 270 coliform organisms per 100 ml.

Laboratory control procedures at Keyport are below the minimum standards set by the Conference of State Sanitary Engineers. The plant performs the following tests: pH of digested sludge - daily; chlorine residual -- four times per day. It is recommended that for this size plant the following additional tests be performed: settleable solids -- daily; BOD and suspended solids of raw and final effluent -- once per week; total solids of digested sludge -- when sludge is drawn.

It is further recommended that at least two operators, one laborer, and six hours per week of administrative supervision be provided. Keyport presently has only one operator; other personnel requirements are met.

MATAWAN BOROUGH

Background

The treatment facility serving Matawan Borough, N.J., was originally constructed in 1923. During 1962 this installation was replaced with a modern, 0.8 MGD primary plant.

Municipal sewage is conveyed to the treatment facility by a separate sewer system, constructed in 1923. Infiltration appears to be a problem, since flow increases significantly during storm periods. Four pumping stations, none of which are provided with a bypass, serve a portion of the system.

Treatment

Treatment includes screening, grit removal, sedimentation-digestion (clarigester) and pre and post chlorination. Sludge is dried on two beds, one of which is covered. Effluent is discharged through an 18-inch outfall into Matawan Creek, a minor tributary to Raritan Bay. Bypassing of the plant, during emergency periods, is possible.

Findings

Performance Summary

Date	Flow	Sus Solids		BOD		Coliform %
	mgd	Eff mg/1	%Rem	Eff mg/1	%Rem	over 1.0/ml
24 hour study						
7-15-64	0.8	82	36	80	39	4
Grab Samples						
8-13-63 to 8-28-63 (3 samples)	-	59	-	139	-	0
10-6-64 to 12-21-65 (14 samples)	0.8	30	-	135	-	21
1-18-66 to 5-18-66 (5 samples)	1.0	118	-	103	-	20

Results of a 24-hour study conducted by the Project, in July 1964, indicated that the effluent did not meet the Compact standards of 60% removal of suspended solids. Bacteriologically, the effluent met the requirements. During the period August 1963 to May 1966, four of the 22 grab samples collected of the effluent had a coliform count of greater than one per ml.

The plant, as presently operated, meets the minimum standards, as set by the Conference of State Sanitary Engineers, for personnel and record keeping. It falls short, however, on laboratory operations, since the plant does not have facilities for analyzing for suspended solids and BOD.

MATAWAN TOWNSHIP

Background

The Matawan Township, N.J., wastewater treatment facility provides secondary treatment for approximately 1,000 persons in the River Gardens section of the community. The installation, constructed in 1953, handles an average daily flow of 80,000 gallons.

A separate sewer system constructed in 1953, serves the area. One pumping station, serving approximately 80 homes -- 250 people -- has been provided. This lift station, equipped with screening devices, cannot be bypassed.

Treatment

Treatment includes primary settling, aeration, secondary settling and chlorination. Sludge is digested in unheated tanks and dewatered in open sand beds. Effluent is discharged through an 8-inch outfall to Matawan Creek, a minor tributary to Raritan Bay.

Findings

Although classified as a secondary plant, this installation during most visits by Project personnel was providing only primary treatment. This condition, which prevailed for almost two years (1964-1965), was usually caused by an inoperable blower system.

Performance Summary

Date	Flow mgd	Sus Solids		BOD		Coliform % over 1.0/ml
		Eff mg/1	%Rem	Eff mg/1	%Rem	
10-14-64 to 12-21-65 (13 samples)	0.05E	74	57	76	63	23
1-18-66 to 5-18-66 (5 samples)	0.05E	106	44	89	53	20

It appears, based on data obtained by the Raritan Bay Project, that this plant is not meeting the Compact requirement of 60% removal of suspended solids.

Bacteriologically, however, the effluent had a count of greater than one coliform per ml in only four out of 18 samples. Data collected indicates that chlorination is relied upon heavily to provide an adequate degree of treatment. Since the plant is manned only two to three hours per day, and because the control of the application of chlorine is poor, the dosage applied during peak flow periods might very well be inadequate. Case in point: All samples with a coliform count of greater than one per ml were taken between the hours of 9:00 and 10:30 a.m.

The plant, as presently operated, does not meet the minimum requirements for laboratory control, as recommended by the Conference of State Sanitary Engineers. No determinations are made for sludge index or dissolved oxygen of the mixed liquor. Minimum personnel requirements are met; however, record keeping falls short of the desired recommendations.

LAURENCE HARBOR (MADISON TOWNSHIP)

Background

The Laurence Harbor, N. J., wastewater treatment installation, previously known as the Knollcroft Plant, 43m was constructed in 1960. The original 0.2 MGD installation, designed to serve a population of approximately 850 people, provided primary treatment consisting of screening, settling, chlorination, digestion, and sludge drying in lagoons.

In 1963 the plant was replaced by a modern 1.2 MGD primary treatment installation. New facilities included screening, grit removal, settling, pre- and post-chlorination, digestion and sludge dewatering by vacuum filter. The only structure retained from the old plant was a digester which was converted into a sludge storage tank. The new complex, which is ultimately designed to serve approximately 3,500 homes, is presently handling wastes from 1,000 homes, representing a tributary population of about 3,500 people and a flow of about 0.5 MGD. Reportedly, there is no change in the population during the summer months. By-passing of raw sewage at the plant is possible; however, wastes must pass the chlorine application point.

The separate sewer system, serving Laurence Harbor and Cliffwood Beach, N. J., is essentially gravity with the exception of two pumping stations which serve small portions of each area. Township officials claim that approximately 65 percent of the sewage comes from Laurence Harbor and the remainder from Cliffwood Beach. These automatically controlled pumping stations reportedly cannot be bypassed. Infiltraction into the four-year-old sewer system is claimed to be negligible.

Treatment

Facilities include a bar screen, grit chamber, two mechanically cleaned sedimentation tanks, chlorine contact tank, two digesters, sludge storage tank and a vacuum filter. The chlorination features of the plant are above average. In addition to practicing pre- and post-chlorination the plant is equipped with a continual residual chlorine indicator-recorder which is tied back to the feed rate. Another feature of the plant is the digester gas mixing and recirculation system.

Reportedly, the sludge dewatering equipment -- a rotary drum-type vacuum filter -- has never been used due to the lack of adequate quantities of sludge. Under normal operations dewatered sludge would be trucked away.

Effluent from the plant discharges directly into Raritan Bay through an outfall line which terminates at a point approximately 1,000 feet offshore.

Findings

The Raritan Bay Project, since August 29, 1963, 45m has conducted three complete 24-hour studies and collected 22 grab samples of the effluent. A summary of the results of these investigations follows:

Performance Summary

Date	Flow	Sus Solids		BOD		Coliform%
	mgd	Eff mg/l	%Rem	Eff mg/l	%Rem	over 1.0/ml
24 hour studies						
8-29,30-63	0.2	81	62	145	49	21
7-7,8-64	0.4	52	64	125	32	0
7-20,21-64	0.5	89	40	163	29	13
Grab Samples						
8-3-63 to 8-28-63 (3 samples)	0.4	42	-	170	-	0
10-6-64 to 12-21-65 (14 samples)	0.6	101		135	-	14
1-18-66 to 5-18-66 (5 samples)	0.6	99	-	95	-	0

The plant met ISC standards for solids removal during two of three 24-hour studies. Bacteriologically, the effluent, during all studies -- 24-hour and grab -- had a count of less than one coliform per ml in more than 50 percent of the samples. It would appear, based on these data, that the plant is discharging an effluent of a quality commensurate with the degree of treatment provided.

The only area where the plant falls short of the recommendations of the Conference of State Sanitary Engineers is in laboratory control. The standards suggest that total solids of digested sludge be run whenever sludge is drawn. Since the plant does not have the proper equipment, they are unable to perform this test.

SAYREVILLE-MORGAN

Background

The Sayreville sewer system is divided into three separate sections, each discharging to a different wastewater treatment plant -- Sayreville-Morgan, Sayrevill-Melrose and Middlesex County Sewerage Authority. The system as a whole serves an area of 15 square miles and a population of 22,600 people.

Paul DeFalco

The Morgan installation, constructed in 1952, is located in the Morgan Section of Sayreville, New Jersey. It provides primary treatment for an average flow of 0.2 MGD and a population of 2,000. The facility is designed for a tributary population of 3,000 people and a flow of 0.3 MGD. The plant can be bypassed, with the sewage being discharged 500 feet west of the plant to a gully which flows into Raritan Bay. During storm periods the installation is subject to flooding, and as a result has at times been forced to shut down.

The sanitary sewer system serving the plant was constructed in 1920. Reportedly, infiltration is not a problem.

Treatment

Treatment consists of screening, sedimentation and chlorination -- both pre and post. Sludge is digested in unheated tanks and dewatered in glass-covered drying beds. Effluent is discharged through an outfall line extending approximately 1,000 feet into Raritan Bay.

Findings

Based on the present average daily flow detention time in the two sedimentation units approaches 6.0 hours. During the summer months this long holding period causes septic conditions; as a result, only one tank is operated during the warmer periods. This type of operation, which was suggested by the New Jersey State Health Department, has reportedly eliminated the septicity problem.

During the period June to August 1964, a representative of the Raritan Bay Project visited the Morgan plant on three different occasions. During all inspections the plant was found to be run-down and inadequately maintained. Such things as a major leak in the outfall line, leaking valves in the digester and a broken concrete weir in the chlorine contact tank were observed during all visits.

50m

Performance Summary

Date	Flow	Sus Solids		BOD		Coliform %
	mgd	Eff mg/1	%Rem	Eff mg/1	%Rem	over 1.0/ml
8 hour study						
7-27-64	0.2	88	77	212	28	33
Grab Samples						
10-6-64 to 12-21-65 (14 samples)	0.2	94		198		21
12-27-65 to 8-1-66	0.2	84		130		0

51m Paul DeFalco

On July 27, 1964, an 8-hour study was conducted at the plant by Project personnel. For this period the solids removal averaged 77 percent and the BOD removal 28 percent. Bacteriologically, six out of the nine effluent samples had a count of less than one coliform per ml.

During this investigation two different methods -- amperometric and colorimetric -- were utilized for determining the chlorine residual. Results of this study follow:

Time	Chlorine Residual (mg/l) Colorimetric	Amperometric Titration	Coliform /100 ml
8:05	10.0+	20.64	10
9:05	10.0+	17.98	30
10:00	5.0	11.79	10
11:00	0.0	2.30	560
12:00	2.0	5.41	260
13:00	3.75	6.75	520
14:00	5.0	9.23	30
15:00	10.0	12.82	20
16:00	10.0	15.02	10

It would appear based on this preliminary study and past observations, that the plant relies heavily upon chlorination to provide an adequate degree of treatment.

52m

Paul DeFalco

Since the control of the application of chlorine is poor, the dosage applied during periods of high flow is inadequate. This condition is brought out in the data for the period between 11:00 to 13:00. Also, it would seem, based on this investigation, economically advantageous for the municipality to adopt the more reliable amperometric method for determining chlorine residual.

SOUTH AMBOY

Background

The South Amboy wastewater treatment plant, owned and operated by the City of South Amboy, New Jersey, was constructed in 1939 to accommodate a design flow of 1.0 MGD. The primary installation is presently serving an estimated population of 8,400 people, and treating approximately 0.85 to 0.9 MGD.

The separate-type sewer system, serving the whole municipality with the exception of one block, has five pumping stations -- Raritan Street, Lower Pine Avenue, Lower Broadway, South Amboy and Thomas Street. Reportedly none of these lift stations, which handle wastes from a tributary population of 800 -- 1,000 people -- are provided by bypasses. The only known bypass is at the treatment plant. Infiltration into the 25-year-old sewer system is claimed to be a problem.

Treatment

Facilities include a bar screen, two circular primary sedimentation tanks, chlorine contact tank, two digesters and a vacuum filter. Effluent from the plant is discharged offshore into Raritan Bay. Bypassed sewage is discharged at the same location.

Findings

Performance Summary

Date	Flow mgd	Sus Solids Eff mg/l	Sus Solids %Rem	BOD Eff mg/l	BOD %Rem	Coliform% over 1.0/ml
24 hour studies						
7-19, 20-62	0.9	-	-	-	-	6
9-6, 7-62	0.9	42	76	117	18	33
11-15,16-62	0.9	56	64	136	21	21
5-26, 27-64	0.8	41	81	70	26	0
Grab Samples						
8-7-62 to 9-11-63 (47 samples)		59		154		17
9-28-64 to 12-27-65 (14 samples)	1.3	75		177		0
12-28-65 to 5-18-66 (5 samples)	0.8	115		138		0

The South Amboy plant, as presently operated, does not meet the minimum requirements for laboratory control as recommended by the Conference of State Sanitary Engineers. The only test performed at the plant is chlorine residual. Recommended is the following: Settleable solids -- daily; pH of raw sewage -- occasionally; total solids, digested sludge -- when sludge is drawn. The installation satisfies the minimum requirements for personnel and approaches the minimum standards for record keeping.

It appears, based on observations by Project personnel, that even though the plant's performance record -- solids and bacteriological -- met ISC requirements during all visitations, the installation is not operated or maintained effectively. Improper operation of the digesters -- hung-up floating cover, bad seal, unrestricted use of lime, insufficient laboratory analyses; and uneven flow from the sedimentation basins -- due to accumulation of grease on the effluent weirs, has been noted.

MIDDLESEX COUNTY SEWERAGE AUTHORITY

Background

Middlesex County Sewerage Authority was

created in 1950; by early 1966 the Authority included 18 municipal and eight industrial participants, representing an area of 96 square miles and a tributary population of 331,000, exclusive of industry. Construction of a central chemical treatment plant was begun in 1955 and the facility was placed in operation in January 1958. Design capacity at that time was 52 MGD. In early 1966, the Authority completed a million dollar expansion program which increased the design capacity to an average flow of 78 MGD and a peak flow of 115 MGD.

The sewerage system consists of the main trunk sewer which runs parallel to the Raritan River, the South River interceptor, and the Sayreville and Heyden pumping stations and force mains. In addition, the system contains the necessary connections to the various participants, a small pumping station in Bound Brook, and metering facilities for each participant. Many of the systems which discharge to the Authority's sewers have overflow devices. The sole overflow in the Authority's trunk sewer is at Landing Lane and is presently locked to prevent discharging.

Raw sewage bypasses are provided at the Sayreville and Bound Brook pumping stations and at the treatment plant. The Sayreville bypass is designed to discharge to Washington Canal; Bound Brook to the Raritan River.

Neither bypass has ever been used. At the treatment plant the bypass runs from the grit chamber to the post-chlorination facilities.

Treatment

Waste (43 MGD) are conveyed to the plant via the Sayreville pumping station and an additional 2 MGD is pumped to the plant from the Heyden station. The Bound Brook station discharges 0.1 MGD to the main trunk sewer. Both the main sewer and the South River interceptor connect to the Sayreville station. All three pumping stations provide screening; in addition, the Heyden and Bound Brook stations are equipped with comminuting devices.

Treatment at the central plant consists of pre-chlorination, grit removal, flocculation, sedimentation, post-chlorination, and sludge thickening. There are no digestion facilities; sludge and grit are loaded on barges for ocean disposal. The plant effluent is discharged to a point approximately 1.5 miles in Raritan Bay.

The plant has a capacity for feeding lime and chlorinated copperas. However, except for a short period during the initial start-up of the plant, chemicals have not been used for treatment since Interstate Sanitation

Commission standards for solids removal reportedly can be met without chemical addition.

Findings

Performance Summary

Date	Flow	Sus Solids		BOD		Coliform %
	mgd	Eff mg/l	%Rem	Eff mg/l	%Rem	over 1.0/ml
24 hour studies						
8-16, 17-62	40.8	74	80	560	17	88
9-20, 21-62	40.0	86	77	558	15	29
11-29, 30-62	48.0	110	72	402	10	8
5-20,21-64	48.5	57	80	458	16	4
Grab Samples						
8-7-62 to 9-11-63 (49 samples)	45.5	89		449		32
9-28-64 to 12-27-65 (14 samples)	51.1	107		396		36
12-28-65 to 5-18-66 (5 samples)	51.5	127		369		40

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During all four 24-hour studies solids removal exceeded the Interstate Sanitation Commission requirements. With the exception of the August 1962 study, effluent coliform counts during the 24-hour investigations were less than 1 per ml, 50 percent of the time.

A review of coliform counts and chlorine residual data indicates that frequently good bacteria kills were recorded with apparently little or no chlorine residual. Due to the high color of the effluent, a study was undertaken to determine the accuracy of the colorimetric method for chlorine residual. A comparison of residual chlorine by colorimetric and amperometric titration methods for the 24-hour study of May 1964 is as follows:

61m

	Chlorine Residual (Total - mg/l)		
Time	Colorimetric	Titrator	Coliform per 100 ml
11:00	5.0	7.9	10
12:00	2.5	5.4	10
13:00	0.0	2.1	10
14:00	2.5	6.6	10
15:00	1.5	6.6	200
16:00	1.0	5.7	10
17:00	0.0	5.2	40
18:00	0.5	5.0	10
19:00	0.0	2.0	10
20:00	0.1	4.0	10
21:00	0.1	4.5	10
22:00	0.25	3.8	10
23:00	-	2.6	30
24:00	0.35	4.4	20
1:00	-	4.7	10
2:00	0.20	3.6	10
3:00	-	3.8	10
4:00	0.60	4.7	10
5:00	-	4.8	10
6:00	2.5	5.8	10
7:00	-	3.0	10
8:00	0.25	2.5	10
9:00	-	4.9	10
10:00	0.25	3.6	10

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These data suggest the amperometric method would be a more reliable technique.

As presently operated the plant more than meets the minimum requirements for operating personnel, laboratory procedures and records, as recommended by the Conference of State Sanitary Engineers.

Project investigations have shown that BOD removals at this plant vary from 10 to 17 percent. This low removal is attributed to high dissolved BOD which is present in the industrial wastes handled. Even with the sophisticated chlorination facilities available, effluent from this plant results in a large BOD load on Raritan Bay. As shown in Table III more than 90 percent of the BOD load to the bay from municipal plants originates from the Middlesex County Sewage Authority discharge.

PERTH AMBOY

Background

Perth Amboy, New Jersey, located at the junction of the Arthur Kill and Raritan River, provides primary treatment for municipal and industrial wastes. During the summer bathing season chemicals are added for increased removals. The 10 MGD plant, constructed in 1934, is designed to serve a population of 50,000 people. The existing tributary population is estimated at 38,000 people and the present flow averages approximately 6.2 MGD. The only addition to the plant since construction has been the installation, in 1956, of sludge dewatering equipment.

The treatment facility, which can be bypassed, discharges at a point 200 feet offshore of the plant site into Raritan Bay. This location is approximately the center of the former public bathing beach of the City of Perth Amboy.

The combined sewer system, serving approximately six square miles, was constructed in 1935 and improved in 1954. There are a total of 18 stormwater overflows in the system -- eight discharging to the Raritan River and 10 to the Arthur Kill. These leaping weir devices are designed to bypass all flows in excess of 1.6 times the average dry weather flow.

Approximately 30 percent of the municipality's wastes are pumped to the plant by two lift stations -- State Street and Front Street. Bypasses are provided at each location with the discharge emptying into the Arthur Kill.

Treatment

Facilities at Perth Amboy include two hand-cleaned bar screens, a pre-aeration mixing chamber, two circular primary sedimentation basins equipped with upward-flow magnetite filters, chlorine contact tank, and two vacuum filters for sludge dewatering. Lime and ferric chloride, used for conditioning the sludge prior to dewatering, are also added to the raw sewage during the bathing season -- May 15 to September 15, during the hours of 7:00 a.m. to 7:00 p.m.

Findings

Magnetite filters at Perth Amboy were originally designed to provide increased removals of colloidal and finely divided suspended solids normally present in the primary effluent. The units had the capacity to handle up to 7 MGD before bypassing to the effluent launder of the settling tanks. However, in early 1960, because of hydraulic limitations and clogged conditions, a series of relief pipes were installed to permit bypassing of primary effluent around the filter beds. This bypassing of a treatment unit has little significance since the State of New Jersey "does not recognize magnetite filters as a treatment method." (Chapter 6.1 - Rules and Regulations for the Design of Sewerage, Water Treatment and Supply Facilities.)

Performance Summary

Date	Flow	Sus Solids		BOD		Coliform %
	mgd	Eff mg/l	%Rem	Eff mg/l	%Rem	over 1.0/ml
24 hour studies						
7-26, 27-62						10
9-13, 14-62	6.8	66	61	193	34	29
11-8, 9-62	5.7	84	56	188	0	8
9-12, 13-63	7.4			111	43	63
5-7, 8-64	4.9	27	72	143	7	21
Grab Samples						
8-7-62 to 9-11-63 (48 samples)	7.3	74		160		56
9-28-64 to 12-27-65 (12 samples)	6.7	117		202		42
12-28-65 to 5-18-66 (5 samples)	6.8	119		166		60

Perth Amboy, during one of the three 24-hour studies, where solids data were collected, failed to meet the ISC standards of 60 percent removal. Bacteriologically, compact requirements of less than one coliform per ml 50 percent of the time, were met during four out of five 24-hour studies. It is noteworthy to point out that the degree of treatment at this plant, which generally increases with the duration of the test period, is not usually duplicated when unannounced random samples are obtained. Case in point: 56 percent of the 48 samples collected from 8-7-62 to 9-11-63 had a coliform count of greater than one per ml.

Visits to the plant by Raritan Bay Project personnel have indicated that this installation is presently inadequately maintained. During all visits massive grease accumulations and scum mats were noticed on the surface of the settling and pre-aeration tanks. As a result, odorous conditions existed in and around the treatment facility. Also noted were inoperable or clogged air headers in the mixing basin.

The treatment facility, as presently operated, does not meet all of the minimum requirements for laboratory control, records, and personnel, as recommended by the Conference of State Sanitary Engineers. BOD of the raw wastes and effluent are run only twice per week - recommended is once daily. Laboratory data, while maintained in a tabular form, were very spotty and gaps of several weeks, where no data were recorded, were noted. For this size plant a minimum of six operators is recommended. Perth Amboy has three.

JUNIOR HIGH SCHOOL NO. 7

Background

During the latter part of 1963, construction was started by the New York City Board of Education on a junior high school, located on Hylan Boulevard and Huguenot Avenue, Staten Island, New York. The facility, which opened in September 1965, is served by a packaged extended aeration plant and sub-surface sand filters.

The treatment installation, designed for a normal flow of 15,000 gpd (2,000 gph on a 7-1/2 hour basis), can handle wastes from a contributing population of 2,128 people -- 2,088 pupils, 66 teachers and 34 maintenance personnel. Flow during the summer months, due to the school's playground and comfort station, is expected to reach 3,000 gpd.

Treatment

Sewage from the upper floors flows to the pumping station by gravity. Wastes from the ground floor and basement, however, flow to a sump in the basement where it is pumped to a manhole in front of the school for gravity flow to the pumping station. All sewage is comminuted prior to entering the wet well, which reportedly has sufficient storage capacity to handle peak flows. Wastes are then pumped to the diversion box where flows in excess of the design rate are returned to the wet well.

After aeration for a period of 24 hours the mixed liquor is settled. Settled sludge is continuously returned by an air lift pump to the aeration tank. Clarified effluent flows to the froth pump wet well, which is a source of water for the froth control spray system. Overflow from the well empties into a dosing tank where alternating siphons discharge sewage onto three sand filters, each 17 x 30 feet. Effluent from the beds is conveyed to the chlorine contact tank prior to its discharge to a storm sewer which empties into Raritan Bay. In the event of a plant shutdown, wastes can bypass the activated sludge unit but not the sand filters and chlorination facilities. Sludge from the holding tank is trucked away and disposed of at the Oakwood Beach Pollution Control Project.

Findings

During the period from October 19, 1966, to August 1966, residuals averaged 2.0 mg/l, with the minimum being 0.6 and the maximum 3.0. Performance data other than seven chlorine residuals collected by the New York City Health Department, are not available.

MOUNT LORETTO

Background

This home and school, owned and operated by the Mission of the Immaculate Virgin, is located on Hylan Boulevard between Richard and Sharrot Avenues, Staten Island, New York. The facility, which covers an area of 895 acres, is served by two separate sewage disposal systems -- one serving the girls' section on the south side of Hylan Boulevard and the other the boys' section on the north side of Hylan Boulevard.

The population served by these treatment facilities is 1,179 people: 415 for the girls' section and 764 for the boys' system. Since no flow indicating or recording devices are available, it is estimated that the average flow from the girls' system is 45,000 gpd and 81,000 gpd from the boys' section.

In April 1962 an order to abate pollution was issued by the New York City Health Department. In 1963 this was complied with by the installation of an automatic hypochlorinator in the girls' section and the installation of a chlorine contact tank and an automatic hypochlorinator in the boys' system.

Treatment

Boys' Section: Facilities consist of one 81,000 gallon capacity septic tank and a 3,600 gallon chlorine contact tank. Contact time is estimated at 35 minutes with an additional 10 minutes in the outfall line, which terminates on the shoreline of Raritan Bay.

During periods of cleaning, which occurs once every three to five years, the system bypasses raw sewage to the bay.

Girls' Section: Facilities include two 22,500 gallon capacity septic tanks and one 2,000 gallon chlorine contact tank. Contact time is estimated at 35 minutes. Effluent is discharged through an 18-inch outfall line which discharges at the shoreline of Raritan Bay.

Findings

The following data were collected by the New York City Health Department (1963-64) and ISC (1965-66):

Plant	Date	Coliform/ml	Chlorine Residual(mg/l)
Girls'	5-31-63	240,000	0
	6-19-63	160,000	0
	10-29-63	92,000	0
	1-8-64	$\underline{/}1$	0
	3-16-64	70	-
	4-14-64	$\overline{/}1$	0
	5-12-64	2,400	0
	6-17-64	2,400	0
	7-15-64	920	0.5
	8-24-64	23	1.0
	8-27-64	$\underline{/}1$	3.5
	9-10-64	2,400	0
	6-28-65	23	3.0
	8-15-66	240	3.0

Plant	Date	Coliform/ml	Chlorine Residual (mg/l)
Boys'	10-29-63	71	trace
	6-19-63	∠1	1
	5-31-63	92,000	0
	1-18-64	78,000	0
	3-16-64	∠1	-
	4-14-64	920	0
	5-12-64	72,400	0
	6-17-64	72,400	0
	7-15-64	∠1	1.5
	8-24-64	∠1	1.0
	8-27-64	71	2.0
	9-10-64	71	1.2
	6-28-65	∠1	3.0
	8-15-66	240	0

It appears, based on these data, that both plants are not meeting the coliform requirements of the Compact. For the girls' system only 2 out of 14 samples, or 14 percent, had less than one coliform per ml. Performance of the boys' plant was equally poor with only 5 out of 14 samples with a coliform count of less than one per ml.

RICHMOND MEMORIAL HOSPITAL

Background

In 1927 a sewer system was installed to serve the hospital located in Princess Bay, Staten Island, New York, and several private homes in the immediate area. In 1936, a septic tank was placed in operation. Eighteen years later, in 1954, a hypochlorinator and a prefabricated chlorine contact tank were added.

A treatment facility, which is located at the corner of Seguine Avenue and Johnston Terrace, is susceptible to flooding during storm periods and unusually high tides.

At the present time, the treatment facility handles wastes from an estimated population of 360 people -- 160 patients, 125 employees, 24 nurses and 16 men in residence, and 12 one-family homes.

In March 1962 the New York City Health Department issued an order to abate pollution. This was complied with in 1963 by improving the chlorination facilities.

Treatment

A 9,800 gallon capacity cylindrical steel

Paul DeFalco

septic tank -- 21 feet long and 9 feet in diameter -- followed by a 500 gallon baffled steel chlorine contact tank provide treatment for the hospital's wastes. Effluent is discharged to Rum Creek, a tributary of Lemon Creek, which empties into Raritan Bay.

Liquid bleach, sodium hypochlorite, is presently being used at the rate of 10 gpd for disinfection. It is estimated that the contact time is approximately 16 minutes.

Findings

Results of investigation conducted by the Interstate Sanitation Commission and the New York City Department of Health follow:

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Sampling Agency	Date	Coliform/ml	Chlorine Residual (mg/l)
ISC	8-16-61	71	-
	5-16-62	71	-
	8-14-62	71	0
	10-24-62	71	0
	5-11-64	∠1	0
N.Y.C. Health Dept.	1-8-64	200	1.5
	3-16-64	2,400	-
	4-14-64	2,400	0
	7-15-64	2,400	0
	8-24-64	2,400	-
	9-9-64	2,400	0.2
	9-17-64	∠1	10+
	9-17-64	∠1	10+
	9-17-64	∠1	35
	9-17-64	∠1	35
ISC	6-28-65	71	0
	6-6-66	72,400	0
	8-16-66	72,400	0

It is evident that Richmond Memorial Hospital is not meeting the coliform requirements of the Compact. It is noteworthy to point out that the degree of treatment increases with the duration of the test period, and that this higher degree of treatment is usually not duplicated by unannounced grab samples. Case in point is the New York City Health Department eight-hour test on 9-17-64, where all samples had less than one coliform per ml. All grab samples collected with only one exception had a coliform count of greater than one per ml.

DAYTOP LODGE (MARIST NOVITIATE)

Background

The home of the Marist Novitiate on Bayview Avenue, Princess Bay, Staten Island, New York, is served by a septic tank system discharging into Lemon Creek. The novitiate had a population of approximately 35 people.

In 1965 the property was sold to Daytop Village, Inc., a group which established the property as a halfway house for drug addicts. Present permanent population at this location is estimated at 80 people. Daytime population may run as high as 200 people.

Findings

Observations by Project personnel, and dye studies conducted by the New York City Health Department, indicate that the discharge line from the septic tank system is broken. Effluent, which is not chlorinated, is presently being discharged through an open ditch into Lemon Creek.

MATAWAN TOWNSHIP: CLIFFWOOD BEACH PLANT #3

Background

The Matawan Township sewage treatment plant No. 3 serves part of the Cliffwood Beach area and a small portion of Cliffwood across New Jersey State Highway 35. This facility, which began operations in January of 1966, provides secondary treatment for approximately 1,200 homes in the area. Designed for a flow of 0.65 MGD, this $500,000 plant is presently handling an average flow of 0.15 to 0.20 MGD. No seasonal fluctuations are expected at this plant.

The collection system is a separate sanitary system with no problems of infiltration reported. Approximately 65 percent of the influent to this plant is handled by five pumping stations, with the remaining influent gravity-fed to the plant.

Treatment

This plant is designed as a Rapid Block system, to treat sewage by the activated sludge process. Treatment includes a barminutor, an aerated de-gritter, three aerated primary settling basins, three aerobic digestion tanks, and a chlorine contact tank.

Grit is removed from the system and hauled away for landfill. Spent sludge from the activated sludge process will be pumped to four drying beds when sufficient sludge is accumulated. This dried sludge will be used in sanitary landfill operations.

The chlorinated effluent is discharged to an unnamed tributary to Whole Creek, a minor tributary to Raritan Bay.

Findings

Two operators, only one of which is licensed, handle the plant. The licensed operator actually serves all three Matawan Township Plants, while the one unlicensed person maintains the plant and performs laboratory tests.

The laboratory facilities are presently performing analyses for BOD, suspended solids, settleable solids, dissolved oxygen, chlorine residual, pH, and relative stability.

Based on one grab sample the suspended solids removal average 89 percent. The coliform count of the effluent was 40 per 100 ml.

ST. JOSEPH'S BY THE SEA

Background

The Sisters of Charity, a Catholic order of nuns, owns and operates this convent and school, located at the southern end of Arbutus Avenue in Huguenot, Staten Island, New York. In September 1964 construction of a high school for girls was completed. The educational institution, located adjacent to the convent, is designed to serve an ultimate population of 910 people -- 840 pupils, 40 nuns, 16 lay teachers, and 14 maintenance personnel.

Treatment

Wastes from the high school and convent are conveyed to the treatment facilities through a 6-inch sewer. Effluent from the two parallel operated septic tanks, each of which measures 15 x 7 x 7.5 feet deep, is discharged into two sand filter beds. The subsurface beds each measure 60 x 155 x 3 feet deep. For disinfection, sodium hypochlorite solution is fed into a chlorine contact tank with a volume of 120 cubic feet. Based on the design flow of 900 gph the contact time is one hour. Chlorinated effluent flows by gravity through a 1,100 foot long, 6-inch diameter outfall line which terminates approximately 300 feet offshore in Raritan Bay. Reportedly, it is impossible to bypass the treatment facilities.

Findings

Septic tank system serving old convent abandoned in 1965, when new facilities started operation.

Sampling Agency	Date	Coliform/ml	Chlorine Residual(mg/l)
ISC	6-18-65	71	0
	6-13-66	∠1	3.0

Paul DeFalco

It would appear that this installation, when it maintains a sufficient residual, can meet the minimum coliform standards of the Compact.

OAKWOOD BEACH

Background

The Oakwood Beach pollution control project, owned and operated by the New York City Department of Public Works, is located on the eastern shore of Staten Island, New York, approximately one mile northeast of Great Kills Harbor. Wastes from the communities of New Dorp, Midland Beach, Oakwood and portions of Dongan Hills, South Beach, and Great Kills are conveyed to the treatment facility through a separate sewer system. Reportedly, no significant amounts of industrial wastes are handled.

The modified aeration plant, constructed in 1956, is designed to handle an average flow of 15 MGD. Four pumping stations, none of which can be bypassed, lift a portion (approximately 60 percent) of the wastes to the treatment facility. The remainder (40 percent) flows to the plant by gravity. The estimated population served by this installation is 85,000 people, and the average flow, based on 1963-64 monthly averages, is approximately 11.0 MGD.

Treatment

Modified aeration and chlorination are employed. This aeration process is normally operated with a two-hour detention time, based on a return sludge rate of 10 percent, and a final settling tank overflow rate of approximately 1,000 gallons per square foot per day. The process is operated satisfactorily without primary sedimentation; however, the final tanks are equipped for removal of the grease load which passes through the aerator.

Unit processes at the plant are screening, grit removal, aeration, final settling, thickening, digestion and chlorination. Digested sludge is disposed of at Marine Park, an area near the plant which is being developed into a recreational area by the Park Department. Treated effluent is discharged directly into Raritan Bay approximately 2,000 feet offshore. The plant bypass is designed to discharge to a drainage ditch which empties into Raritan Bay.

In January 1964 the treatment plant changed its disinfection arrangement so that 15 percent sodium hypochlorite would be used rather than liquid chlorine. This modification was reportedly made for reasons of safety. Based on plant records, hypochlorite consumption is 350 gpd. An automatic chlorine residual recorder has been installed; however, it is not connected to the bleach feed rate.

Findings

Performance Summary

Date	Flow mgd	Sus-Solids		BOD		Coliform % over 1.0/ml
		Eff mg/1	%Rem	Eff mg/1	%Rem	
24 hour studies						
8-2,3-62	8.4	37	77	81	57	8
9-27,28-62	11.6	47	82	-	-	29
1-10,11-63	8.8	-	-	20	82	0
5-5,6-64	10.5	26	62	-	-	38
Grab Samples						
8-7-62 - 9-10-63 (49 samples)	10.9	23	-	17	-	29
9-28-64 - 12-27-65 (14 samples)	8.2	106	-	41	-	43
12-28-65 - 5-20-66 (5 samples)	6.7	45	-	31	-	40

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Project personnel have conducted four 24-hour comprehensive studies and collected 68 grab samples of the effluent. Suspended solids removal during extended studies met the Compact requirements of 60 percent. During all sampling programs -- 24-hour, grab -- the coliform requirements were met.

The plant, as presently operated, more than adequately meets the minimum requirements for personnel, record keeping and laboratory control as recommended by the Conference of State Sanitary Engineers.

It would appear, based on preliminary investigations conducted by the Federal Water Pollution Control Administration, that infiltration into the sewer system is quite significant, possibly reaching as high as 3.0 MGD. Since chloride levels in the raw wastes do not fluctuate it would appear that infiltration is due possibly to fresh groundwater.

WOODBRIDGE-SEWAREN

Background

The Woodridge-Sewaren treatment plant serves a 3.4 square mile area of Woodbridge Township, New Jersey.

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The 1960 population served was approximately 30,000 people. The facility, constructed in 1954 to accommodate a maximum design flow of 10.0 MGD, is presently handling 3.9 MGD. Flows exceeding 10 MGD are bypassed to the Arthur Kill.

A separate sanitary sewer system, which is known to have an infiltration problem, serves the area. Industrial connections to the system are few in number.

Effluent from this facility is discharged to the Arthur Kill in Class B waters, where the ISC requirement is 10 percent removal of suspended solids and no reduction of coliform organisms. At the request of ISC the Sewaren plant installed chlorination facilities in 1962.

Treatment

Treatment facilities include two mechanically cleaned grit chambers; two bar screens, two aerated flocculation units; two sedimentation tanks; two sand filters; chlorine contact tank; and two vacuum filters.

The sand filters have been out of operation for several years and are not providing treatment.

Findings

Performance Summary

Date	Flow	Sus Solids		BOD		COD		Coliform % over
	mgd	Eff mg/l	%Rem	Eff mg/l	%Rem	Eff mg/l	%Rem	1.0/ml
*5-25, 26-65	3.9	83	51	134	35	346	28	4.0
6-24-65		55	89	111	23			100
8-18-65	2.1	59	92	76	58			0
9-22-65	2.5	60	83	130	--			100
10-26-65	1.5	83	5	123	15			100
11-30-65	2.3	89	75	124	30			0
12-28-65	2.7	77	59	59	69			0
1-18-66	2.6	158	16	134	18			0
2-16-66	2.8	30	--	11	73			0
3-24-66	3.8	73	45	38	34			100
4-19-66	8.5	59	47	80	11			100
5-18-66	2.4	41	--	56	3			100

*24-hour study (25 samples)

New Jersey State Health Department has issued orders against Sewaren to provide secondary treatment.

CARTERET

Background

The Carteret treatment plant, constructed in 1953 to handle an average flow of 3.0 MGD, serves the Borough of Carteret, New Jersey. Present tributary population is approximately 15,000 people.

A combined sewer system, covering an area of approximately 4.5 square miles, serves the plant. Storm water overflows are located at seven points in the system -- six discharge to the Arthur Kill and one to the Rahway River. All regulators are reportedly controlled by float valves.

Effluent from this primary treatment facility is discharged to the Arthur Kill approximately 4,000 feet south of the mouth of the Rahway River. This section of the Kill is Class "B" water. In 1962, however, at the request of the ISC, chlorination facilities were provided.

Treatment

Treatment consists of screening, grit removal, sedimentation and chlorination. Sludge is dewatered on vacuum filters and disposed of at a landfill site. Sand filters were initially constructed; however, they are presently out of operation.

Findings

Performance Summary

Date	Flow	Sus Solids		BOD		COD		Coliform %
	mgd	Eff mg/1	%Rem	Eff mg/1	%Rem	Eff mg/1	%Rem	over 1.0/ml
*5-27,28-65	2.5	80	68	134	41	384	24	56
6-24-65	2.4	68	79	84	38			100
8-18-65	2.7	76	65	102	39			100
9-22-65	2.5	96	45	100	40			100
10-26-65	2.6	94	66	130	45			100
11-30-65	3.0	89	57	76	53			0
12-28-65	3.4	153	5	86	53			0
1-18-66	2.5	109	72	69	61			0
2-16-66	3.5	64	86	18	69			0
3-24-66	2.6	134	62	82	63			100
4-19-66	2.3	41	45	31	62			0
5-18-66	2.7	43	37	12	86			0

*24-hour study (25 samples)

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New Jersey State Health Department has issued orders against Carteret to provide secondary treatment. The facility as presently operated is not meeting the coliform requirements of the Compact. During a 24-hour study conducted by the Project only 11 out of 25 samples had a coliform count of less than one coliform per ml. Five of 11 grab samples, collected during an 11-month period, had greater than one coliform per ml.

RAHWAY VALLEY SEWERAGE AUTHORITY

Background

The Rahway Valley Sewerage Authority handles wastes from the communities of Springfield, Kenilworth, Cranford, Roselle Park, Westfield, Norwood, Clark, Woodbridge and Rahway, New Jersey. Approximately 70 industrial plants are tributary to the system, including Merck & Co., U. S. Gypsum, and White Pharmaceutical Co.

The Authority serves an area of 45 square miles which is limited by contract. The 1960 sewered population was estimated to be 180,000 people. There are reportedly no significant seasonal population changes.

This primary treatment facility, constructed in 1927, treats an average flow of 24 MGD, a minimum of 19 MGD, and a maximum of 31 MGD. The sewer system consists of both combined and separate sewers. There are six storm water overflows. Infiltration during storms is a problem, as flow increases 25 to 40 percent during these periods.

The outfall line, which is about three to four miles long, discharges into the Arthur Kill in Class "B" waters -- about 2,500 feet south of the Rahway River outlet.

Treatment

Treatment consists of screening, grit removal, pre-chlorination, sedimentation and digestion. Sludge -- both primary and digested -- is pumped to the Linden-Roselle plant for storage and consequent barging to sea.

Findings

Performance Summary

Date	Flow	Sus Solids		BOD		COD		Coliform %
	mgd	Eff mg/1	%Rem	Eff mg/1	%Rem	Eff mg/1	%Rem	over 1.0/ml
*6-9, 10-65	19.7	79	55	184	27	436	21	No chlorination req.
6-24-65	30.0	93	72	124	15			" " "
8-18-65	23.0	42	60	142	11			" " "
9-22-65	25.0	80	72	155	4			" " "
10-26-65	25.0	77	74	121	30			" " "
11-30-65	24.0	71	67	169	22			" " "
12-28-65	24.0	92	58	179	43			" " "
1-18-66	26.0	73	69	220	--			" " "
2-16-66	30.0	53	52	144	--			" " "
3-24-66	26.0	111	61	173	21			" " "
4-19-66	10.0	152	--	232	31			" " "
5-18-66	18.5	56	81	237	--			" " "

*24-hour study

New Jersey State Health Department has issued orders against the Authority to provide secondary treatment. Pilot facilities are presently being operated to determine method of treatment.

LINDEN-ROSELLE

Background

The Linden-Roselle plant handles wastes from the communities of Linden and Roselle, New Jersey. About one year prior to World War II, the Interstate Sanitation Commission ordered these cities to stop polluting the tidal waters of New Jersey. Due to the emergency of the war a number of extensions were granted to the two municipalities. After the war, it was decided to construct a plant as a joint project. This primary treatment facility, designed to handle an average flow of 12.5 MGD, was completed in 1952. It presently serves a population of approximately 120,000 people.

The cities are each served by separate sanitary sewer systems which reportedly have no infiltration problems. Each municipality has an ordinance requiring connection to the sewer. Approximately 20 percent of the population equivalent load to the plant results from industrial discharges.

The 1964 hydraulic load was as follows:

Minimum day	7 MGD
Average day	10 MGD
Maximum day	18 MGD

Effluent discharges to the Arthur Kill. Raw sewage bypasses are located on the Kill near the Esso Bayway Refinery and at Morses Creek.

Treatment

Treatment consists of screening, grit removal and sedimentation. Raw sludge from this facility, as well as digested and primary sludge from the Rahway Valley plant, is stored in tanks prior to barging to sea.

Findings

Performance Summary

Date	Flow	Sus Solids		BOD		COD		Coliform % over
	mgd	Eff mg/l	%Rem	Eff mg/l	%Rem	Eff mg/l	%Rem	1.0/ml
*6-14, 15-65	7.9	109	68	334	37	625	-	No chlorination req.
6-24-65	12.0	156	58	350	--			" " "
8-18-65	12.0	71	56	541	--			" " "
9-22-65	11.0	155	48	602	--			" " "
10-26-65	11.0	58	82	299	49			" " "
11-30-65	11.0	136	51	850	--			" " "
12-28-65	8.0	70	39	352	6			" " "
1-18-66	11.0	77	73	322	25			" " "
2-16-66	15.0	171	50	534	--			" " "
3-24-66	10.0	192	--	359	49			" " "
4-19-66	10.0	156	43	613	5			" " "
5-18-66	10.5	107	--	488	22			" " "

*24-hour study

98m

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New Jersey State Health Department has issued orders against Linden-Roselle to provide secondary treatment. Plant presently operating pilot facilities to determine system for handling their wastes.

JOINT MEETING

Background

The Joint Meeting Plant provides primary treatment for wastes from the communities of East Orange, Hillside, Irvington, Maplewood, Newark, Millburn, Roselle Park, South Orange, Summit, Union, West Orange, and Elizabeth, New Jersey. The facility, constructed during the period 1931-37, had a 1950 connected population of 475,000 people.

The hydraulic loading during 1964 was as follows:

Minimum day	38.0 MGD
Average day	53.5 MGD
Maximum day	114.0 MGD
Peak hour	178.0 MGD

All of the communities with the exception of Elizabeth, which has a combined system, have separate sewers. Storm waters from Elizabeth discharge to the Arthur Kill. Infiltration, which is a problem in some locations, is the responsibility of the individual areas.

All participants have ordinances that require connection to the sewer system. Connection of industrial facilities to the sewers is the responsibility of the particular municipality. It is estimated that half of the present flow is of industrial origin.

Treatment

Treatment consists of screening -- coarse and fine; grit removal in four mechanically cleaned units; and sedimentation in four rectangular tanks equipped with mechanical sludge and scum collectors. Sludge from the settling units is pumped to two 70-foot diameter by 28.5 foot deep storage units. Disposal of sludge -- 25 trips per year -- is by barging.

Effluent from this facility, which is presently not chlorinated, is discharged to the Arthur Kill at the foot of Clifton Street in Elizabeth. The treatment facilities cannot be bypassed.

Findings

100m

Performance Summary

Date	Flow	Sus Solids		BOD		COD		Coliform % over 1.0/ml		
	mgd	Eff mg/l	%Rem	Eff mg/l	%Rem	Eff mg/l	%Rem			
*6-16,17-65	47.4	78	64	191	23	356	34.2	No	chlorination	req.
6-24-65	63.0	92	60	104	53			"	"	"
8-18-65	66.0	92	16	173	39			"	"	"
9-22-65	60.0	217	--	249	--			"	"	"
10-26-65	26.0	127	2	93	28			"	"	"
11-30-65	25.0	46	60	115	7			"	"	"
12-28-65	-	51	40	137	0			"	"	"
1-18-66	29.0	48	69	124	12			"	"	"
2-16-66	81.0	154	26	158	17			"	"	"
3-24-66	38.0	58	46	81	2			"	"	"
4-19-66	55.0	121	31	244	38			"	"	"
5-18-66	65.0	91	65	108	50			"	"	"

*24-hour study

New Jersey State Health Department has issued orders against Joint Meeting to provide secondary treatment. Plant is presently operating pilot facilities to determine the most efficient treatment system.

KEASBY

Background

The Keasby wastewater treatment plant, constructed in 1940, serves a small portion of Woodbridge, New Jersey. The facility handles municipal sewage, from a tributary population of approximately 3,000 people, and wastes from several petro-chemical industries. Designed to treat 1.25 MGD, the plant will automatically bypass flows in excess of this amount.

The sewer system, constructed in 1900, reportedly has no serious infiltration problems.

Treatment

Keasby was originally designed as an intermediate-type treatment plant utilizing magnetite filters. Present operation is primary -- filters inoperative; also filters not recognized by the State as a treatment method.

Treatment at Keasby includes screening, grit removal, sedimentation, chlorination and digestion. Sludge is dewatered on glass-covered sand beds.

Findings

During visitations by Project personnel, it was learned that approximately 200 lbs/day of lime are being added to the raw sewage between the hours of 7:00 a.m. and noon. Whether or not the addition of this chemical improves treatment is questionable since no data were available.

Performance Summary

Date	Flow mgd	Sus Solids Eff mg/l	Sus Solids %Rem	BOD Eff mg/l	BOD %Rem	Coliform % over 1.0/ml
24-hour studies						
5-14,15-64	0.8	62	58	73	30	0
Grab samples						
10-6-64 to 12-28-65 (14 samples)	0.9	82	--	90	--	7
1-18-66 to 5-18-66 (5 samples)	1.0	77		57		20

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During the 24-hour study conducted in May 1964, solids removal was only 58 percent. Bacteriologically, all 24 samples during this study had a coliform count of less than 1.0 ml. Of the 19 grab samples obtained between October 1964 and May 1966, two had a count of greater than 1.0 coliforms per ml.

The plant, as presently operated, meets the minimum standards as set by the Conference of State Sanitary Engineers, for laboratory control, record keeping and personnel.

SAYREVILLE-MELROSE

Background

The Melrose wastewater treatment plant, serving the Melrose section of Sayreville, New Jersey, was constructed in 1949 to accommodate a design flow of 0.1 MGD. Present population served is approximately 1,000 people, with an average flow of 0.05 MGD.

Treatment

Treatment includes screening, sedimentation, chlorination and digestion. Sludge is dewatered in glass-covered drying beds. Effluent discharges to the Raritan River, upstream of the Garden State Parkway Bridge.

Findings

Performance Summary

Date	Flow	Sus Solids		BOD		Coliform %
	mgd	Eff mg/l	%Rem	Eff mg/l	%Rem	over 1.0/ml
10-16-61	.046	-	-	-	-	0
3-5-62	.013	40	61	88	36	0
4-3-62	.015	40	59	93	40	0
5-9-62	.031	40	77	121	42	0
7-2-62	.036	79	63	184	35	0
8-21-62	.029	58	63	125	30	0
10-8-62	.034	62	40	130	8	0
11-29-62	.031	51	18	94	neg	0
2-6-63	.024	50	40	140	3	0
3-18-63	.031	36	38	101	17	0
3-16-64	.032	49	80	215	52	25
5-5-64	.025	36	63	154	41	0
6-17-64	.014	57	65	69	63	0
11-3-64	.030	72	58	162	31	0
2-16-65	.031	36	62	102	40	75
4-21-65	.040	101	34	157	22	0
8-9-65	-	61	48	118	38	0
11-3-65	.030	72	58	162	31	0
2-17-66	.040	40	61	98	45	0
5-4-66	0.06	27	69	107	21	0

Inspections by the Interstate Sanitation Commission since October 1961 have shown that the plant failed to meet the Compact requirements for suspended solids removal on nine out of the 20 occasions. Bacteriologically, the facility failed to meet the coliform requirements only once.

RARITAN DEPOT

Background

Constructed originally in 1917, this secondary treatment plant was expanded in 1944 by the U. S. Army Engineers. In 1964, with the closing of the Raritan Arsenal, the plant, along with a large portion of Arsenal property, was turned over to Middlesex County, New Jersey, which now operates the plant.

A separate sewer system, constructed in 1917, serves the area. All flow is by gravity, and reportedly infiltration is a problem.

Treatment

Treatment includes screening, sedimentation, biological treatment -- fixed nozzle trickling filters, chlorination and digestion. Sludge is dewatered on open drying beds. Effluent from the plant discharges to a small creek which is tributary to the Raritan River.

Findings

Date	Flow mgd	Sus Solids		BOD		Coliform % over 1.0/ml
		Eff mg/1	%Rem	Eff mg/1	%Rem	
10-6-64 to 12-28-65 (13 samples)	0.05E	17	45	10	63	0
1-18-66 to 5-18-66 (5 samples)	0.06E	9	70	2	94	20

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Eighteen grab samples were collected by the Project during the period October 1964 to May 1966. Only one out of 18 had a coliform count of greater than 1.0 per ml.

The plant, as presently operated, is underloaded. During 1961, when the Arsenal was in operation, flow averaged 250,000 to 300,000 gpd. Due to the present low flow the trickling filters are not biologically active. Low BOD and solids in the effluent is attributed to dilution with infiltration and air-conditioning cooling waters. The present daytime population served is estimated at 300 people; during the evening hours this decreases to approximately 10 people.

Conditions at the plant most likely will change as the county opened a junior college in September 1966 on the old arsenal property. Ultimate student population is estimated to be 800 people.

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SOURCES OF POLLUTION

STORMWATER OVERFLOWS

NAVIGATION & RECREATIONAL BOATING

INDUSTRIAL WASTES

STORMWATER OVERFLOWS

The major combined sewer system with stormwater overflows discharging directly to Raritan Bay is Perth Amboy, New Jersey. This combined sewer system has a total of 19 overflow outlets. During the summer of 1961, the New Jersey State Department of Health conducted an extensive study which indicated that significant overflow begins when the registered plant flow rate is between 10 and 10.5 MGD. No diversion occurred in any of the chambers when the plant influent rate was 8.5 MGD or less.

An analysis of plant influent pumping charts for the period August 1960 to July 1961 indicated that the influent flow at the plant was less than 8.5 MGD 90.2

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percent of the time. The influent flow rate was between 10.0 and 10.5 MGD only 0.3 percent of the time. Flows greater than 10.5 MGD occurred for 12 hours during the year, or about 0.1 percent of the time.

To estimate the order of magnitude of loadings upon Raritan Bay from the overflow of the Perth Amboy system, a storm was assumed which results in a total rainfall of one inch over a 24-hour period. Weather Bureau records at New Brunswick and Rahway, New Jersey, indicated that storms with a daily rainfall of one inch or greater occurred 23 times during the 31-month period May 1962 through November 1964, or nine percent of the time. More than half of these storms occurred during the summer months, May through September.

The Perth Amboy sewer system serves an area of 1.50 square miles. Assuming complete runoff and a normal dry-weather sewage flow of 6.2 MGD, the assumed storm would result in a total discharge of 32 MGD. With diversion of all flows over 10 MGD, 22 MGD of combined sewage and stormwater could be discharged to the Bay. With complete mixing, and no added BOD loading from stormwater runoff, the BOD load diverted would be approximately 7,000 lbs/day. While it is true that with the observed frequency of such storms the total BOD load, on a yearly basis would amount to only

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170 lbs/day -- 25 percent of the normal load imposed by the Perth Amboy plant discharge -- such loads are imposed over a short period of time and do constitute a problem. Equally significant is the bacteriological degradation which results from the discharge of unchlorinated raw municipal sewage during the bathing season. Such contamination represents a hazard to those persons using these waters for recreational activities following summer storms.

Combined sewers serving the Tottenville area of Staten Island, New York, also discharge overflows into Raritan Bay. Similar systems serving easterly Staten Island and the Red Hook section of Brooklyn, New York, discharge overflows to Upper Bay in the immediate vicinity of the Narrows. Since sewage from this same area is discharged without treatment, the effects of such overflows are not significantly different from those resulting from the normal discharge of raw sewage. However, once adequate treatment and disinfection have been provided to normal sewage from this area, the overflow of combined sewage will still present a bacteriological hazard to users of these waters in the same manner as described for Perth Amboy.

Hence, at present, the effects of stormwater discharges on water quality in Raritan Bay are masked by the large volume of raw sewage discharges. Separation of these two effects is not possible with present technology.

POLLUTION FROM NAVIGATION AND RECREATIONAL BOATING

Raritan Bay is widely used for both commercial navigation and recreational boating. Both of these uses result in pollution of the study area waters. The Project reviewed existing information on commercial navigation and conducted a survey of recreational boating to determine the magnitudes of loads from these respective sources.

The major problem of fecal pollution from commercial vessels was found to be concentrated in the berthing areas where the equivalent population was estimated at 600 persons. Pollution from vessels in anchorage or in transit was found to be equal to a population of less than 100 persons. These figures do not include pollutional loads which occur as a result of discharge of oil and other bilge wastes, discard of garbage, trash and other debris, and spillages at dockside during cargo transfer.

The pollution loads associated with recreational boating occur as a result of discharge of human wastes, contamination from fuel and oil by spillage and engine exhausts, discard of trash and garbage, and use of chumming bait when boats are involved with fishing activities. It was estimated that the pollution load to Raritan Bay from recreational boating is presently 725 lbs/day of BOD. The fecal bacterial loading was estimated as that associated with the raw discharge from nearly 6,000 persons. The source of pollution from recreational boating is spread uniformly over Raritan Bay rather than being located at a particular point, as would be the case for the discharge from a municipal treatment plant. The magnitude of this pollution load, however, is sufficient to warrant further study and the development of adequate treatment facilities to insure control of pollution from these sources.

INDUSTRIAL WASTES

General

Sources and characteristics of industrial wastes discharged to Raritan Bay, Arthur Kill and Raritan River are described in this section. Table V summarizes the total wastes flow with a breakdown by major industry type. Table VI presents specific information on the various industries throughout the study area. These data have been compiled from a number of sources. All of the industries listed were visited by the Project, and in a number of cases sampling and analyses of the wastes effluents were performed. Much of the data presented were provided by the industries as a result of their wastes monitoring programs, or calculations of a material balance. Information was obtained also from the Interstate Sanitation Commission, New Jersey State Department of Health, and New York City Department of Health.

Raritan Bay receives the direct discharge from two industries. Wastes from International Flavors & Fragrances, Inc., which amounts to 2,500 lbs/day of BOD, are discharged on an intermittent basis. The S. S. White Co., discharges approximately 0.5 MGD of treated wastes.

Arthur Kill receives the wastes discharge from 21 industries and three power generating stations. The 21 industries discharge a total of 320 MGD, imposing a loading of more than 100,000 lbs/day of BOD and 187,000 lbs/day of COD upon the Kill. In addition to these oxygen demanding wastes the Kill receives 10 tons per day of oil and 4.0 tons per day of phenol from the sources shown in Table VI. The three power generating stations, which use 1,660 MGD of Kill water for cooling purposes, pollute the waters with an estimated 200 billion BTU's per day of heat. The total industrial wastes flow to the Arthur Kill from both process industries and power generating stations amounts to nearly

2,000 MGD.

As of January 1, 1967, 10 industries discharged to the Raritan River and two power plants utilized it as a source of cooling water. Of the 10 industries, one -- Hatco Chemical, Division, W. R. Grace & Co. -- is scheduled for connection to the Middlesex County Sewerage Authority trunk sewer early in 1967. Seven of the remaining industries participate at least partially in the same trunk sewer system. However, a number of these industries return contaminated cooling waters to the Raritan River, thus imposing a pollutional load. The plants on the waterway, exclusive of power stations, discharge 85 MGD of wastes with a BOD loading of 70,000 lbs/day. The power stations utilize 400 MGD of cooling water, resulting in thermal pollution of 33 billion BTU's per day of heat.

Sources

Industries listed in Table VI were visited by Project personnel during the period April 1965 through February 1966. During these meetings with company officials plant operations -- processes, capacity, water consumption, waste discharges, raw materials -- were reviewed. Summary reports of each visit are included in this section.

TABLE V

INDUSTRIAL WASTE SUMMARY

Industry Type	No. of Sources	Flow MGD	Loadings in lbs per day						Pop. Equiv. (BOD)	Other Pollutants
			BOD	COD	Phenol	Oil	P	Total N		
ARTHUR KILL										
Petroleum	4	279.3	51,930	128,100	6,780	16,325	350	5,175		
Chemical	9	38.4	40,370	58,290	3,990	3,240	3,000			
Metal	4	43.7	--	--	--	Ins				
Power Generation	3	1,659.0	--	--	--	--	--	--		Trace Metals and Oil 20×10^{10} BTU Heat
Miscellaneous	4	5.9	12,340	1,280		280				
Total, Arthur Kill	24	2,026.3 (367.3)	104,640	187,670	10,770	19,845	3,350	5,175	615,000	
RARITAN BAY										
Power Generation	1	100.0								0.8×10^{10} BTU Heat
Miscellaneous	2	0.1	2,500							
Total, Raritan Bay	3	100.1 (0.1)	2,500						14,700	
RARITAN RIVER										
Chemical	8	71.9	67,825	45,250	Ins					
Power Generation	1	300.0								2.5×10^{10} BTU Heat
Miscellaneous	2	13.8	2,275							
Total, Raritan River	11	385.7 (85.7)	70,100	45,250					421,000	

TABLE VI - INDUSTRIAL WASTE DISCHARGES

PETROLEUM INDUSTRY

Name	Flow MGD	BOD	COD	Loadings (lbs/day) Phenol	Oil	P	NH_3-N	Total N	Receiving Water	Remarks
Humble	212.7	46,920	102,600	6,640	15,000	320	2,800	3,200	Arthur Kill	1
Chevron	56.0	2,150	13,100	40	none	10	520*	1,275	" "	1*includes 635 lbs/day NO_2-N
Hess	1.6	990	4,000	90	300	10	640	660	" "	1
Citgo	9.0	1,870	8,400	10	1,025	10	40	40	" "	1

CHEMICAL INDUSTRY

Name	Flow MGD	BOD	COD	Loadings (lbs/day) Phenol	Oil	P	NH_3-N	Total N	Receiving Water	Remarks
American Agricultural	-	-	-	-	-	500			Arthur Kill	2 Estimated P
DuPont - Grasselli		-	-	2,500 (See specific report)					Arthur Kill	2 Material Bal.
FMC	5.6	40	-	-	-	2,000			Arthur Kill	2,3
Reichhold Chem., Carteret	0.2	Neg.	Neg.	Neg.					Arthur Kill	2,3
American Cyanamid, Linden	6.4	7,970	-	-	-	-			Arthur Kill	2,3
" " Woodbridge	0.1	Neg.	-	-	-	-			Arthur Kill	2,3
General Aniline	26.0	31,800	57,500	1,490	3,240	-			Arthur Kill	2,3
Armour Agricultural	-	-	-	-	-	500			Arthur Kill	2,3
Sinclair-Koppers	0.1	560	790	-	-	-			Arthur Kill	2,3
Union Carbide	0.6	235	1,700	20	-	-			Raritan River	2,3,4
National Lead	43.0	-	-	-	-	-	H_2SO_4 5000# $FeSO_4$ 3000#		Raritan River	2,3,4
Amer. Cyanamid B. Brook	22.5	*3,600 to 28,000	-	-	-	-			Raritan River	2,3 *seasonal variation
Hatco	1.3	36,830	42,350	-	-	-			Raritan River	2,3,4
Tenneco	1.2	600	1,200	-	-	-			Raritan River	2,3,4
DuPont-Photo Products	-	1,000	-	-	-	-			Raritan River	2,3,4
DuPont-Finishing	-	360	-	-	-	-			Raritan River	2,3,4
Hercules Powder	3.3	800	-	-	-	-			Raritan River	2,3,4

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METALS INDUSTRY

Name	Flow MGD	Cu	Loadings (lbs/day) Pb	Oil	Ni	Receiving Water	Remarks
Amer. Smelting & Ref.	7.7	55	nil			Arthur Kill	1,2,5
U.S. Metals	35.8	165	nil		200	Arthur Kill	1,2,5
Phelps Dodge	.07	30		20		Arthur Kill	2,5
Nassau Smelting	0.10	75	60			Arthur Kill	1,5

POWER GENERATION INDUSTRY

Name	Flow MGD	Temp. Increase of	BTU per day	Receiving Water	Remarks
Public Service, Sewaren	910	15	11.4 x 10^{10}	Arthur Kill	2
Public Service, Linden	345	15	4.3 x 10^{10}	Arthur Kill	2
Consolidated Edison	404	13	4.4 x 10^{10}	Arthur Kill	2
South Amboy Power & Light	100	10	0.8 x 10^{10}	Raritan Bay	2
Jersey Central, Sayreville	300	10	2.5 x 10^{10}	Raritan River	2

MISCELLANEOUS INDUSTRIES

Name	Flow MGD	BOD	COD	Chrome or Cr	CN	ABS	Suspended Solids	Oil	Receiving Water	Remarks
International Flavors & Fragrances	0.04	2,500							Raritan Bay	Intermittent 2
S.S. White	0.05	-	-	2	0.33				Raritan Bay	2,3
Procter & Gamble	5.4	12,000				240	4,600		Arthur Kill	2,3
General Amer. Transp.	.01		Trace loadings only						Arthur Kill	2
Archer Daniels Midland	.44	200	1030	-	-	-	-	240	Arthur Kill	Negl. phenol ISC & NJ 2,3
Koppers Wood Preserving	.005	140	250	-	-	-	-	40*	Arthur Kill	*6#/day phenol 2,3
Johns-Manville	13.3	2,100	-	-	-	-	2,100	-	Raritan River	2,3
Philip Carey	0.50	175					45		Raritan River	2,3

TABLE VI - INDUSTRIAL WASTE DISCHARGES

REMARKS KEY

1. Based on sampling by Project.
2. Company supplied data.
3. Data supplied by either State Health Department, ISC or MCSA.
4. Cooling water discharged; MCSA participant.
5. Cooling water discharge.

Humble Oil & Refining Co., Bayway Refinery, Linden, New Jersey

1. Organization:

The Bayway Refinery is located at the eastern edge of Linden, New Jersey, between U. S. Highway 1 and the Arthur Kill. The refinery property consists of some 1,400 acres which includes tank farm areas. The modernization program and consolidation of equipment has left considerable open space in the process areas.

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This refinery dates back to 1908. It was originally operated as Standard Oil of New Jersey. Through the years the Bayway Refinery has been outstanding in the petroleum refining industry.

The Clean Water and Air Effluent improvement activity at Bayway is carried out by ten men who devote most of their time to waste control. This unit includes one full-time laboratory technician. Dr. W. H. Lang, Staff Consultant, Esso Research and Engineering Company, Florham Park, New Jersey, represents the Bayway Refinery on the A.P.I. Wastes Disposal Committee. Through Dr. Lang, the Bayway Refinery personnel engaged in waste control are kept informed on new developments in the petroleum industry pertaining to liquid wastes control and treatment.

2. Products:

Humble Oil and Refining Company presently markets some 2,000 different petroleum products. The trend at Bayway Refinery is toward diversification, but most of the products continue to be large volume production. Production is geared to continuous flow rather than batch operations.

The principal products run at this refinery are:

Fuel gas
Ethylene
Isobutylene
S.B.O.H.
M.E.K.
Acetone
MIBK-MIBC
Isophorone
Paratone & Vistanex
L.P.G.
Polymer chemicals

MO gas
Jet
Diesel
Heating oil
Clarified oil
Fuel oil
Asphalt
Lube additives
Turbo oil
White oil & trans. oil
Sulphonates

3. Raw Materials:

Crude oil is received by tankers from the Gulf of Mexico and South America. These crudes vary considerably but would be classified either mixed base or asphalt base. These are essentially sweet crudes, the sulfur concentration seldom exceeding 2.5 percent. Salt concentration in the crude runs about five pounds per a thousand barrels of crude.

Raw materials vary with the end products and the treatment processes employed. This is particularly true in the Chemical Products Department. The refinery proper will normally use significant quantities of sulfuric acid, caustic, lime, soda ash, ammonia, catalysts, diethanolamine, and others.

4. Capacity:

This refinery has a capacity for refining 172,000 barrels (42 gallon-barrel) of crude oil per day. Crude intake does not completely reflect effluent characteristics because of the practice of processing intermediate products received from affiliate refineries. Design of much of this process equipment permits flexibility in operation.

5. Operations:

The pipe stills, catalytic cracking unit and auxiliary equipment operate continuously. The pipe stills are distinctly segregated from catalytic cracking with considerable intermediate storage for gas oil. A large number of tanks are utilized to minimize the effect of demand for seasonal products. Many of the secondary treatment processes are continuous. Although there are certain batch-type treatment processes with intermittent discharge, refinery operations are essentially on a 24-hour day, seven-day week basis.

6. Water Supply:

Three sources of water are available, namely, Arthur Kill, surface reservoirs, and Elizabethtown public water supply. The Elizabethtown water is used for drinking and sanitary purposes.

The bulk of water for the refinery is pumped from the Arthur Kill and is used for cooling purposes. The relative quantity of salt water to fresh water was not known, but Arthur Kill water was believed to represent approximately 99 percent of the total water used. The only treatment given Arthur Kill water is "slug chlorination," once each shift, winter and summer.

West Brook and Peach Orchard Creek are the source of runoff water. Within the refinery, these streams are impounded into a series of reservoirs upstream from No. 2 Dam. Some of this reservoir water is pumped to Public Service Electric and Gas Company in exchange for steam furnished the Bayway Refinery, and some is pumped to Esso's water treating unit and to other limited use within the refinery.

7. Sewerage:

There are four entirely separate sewer systems within the refinery. These are:

a. Sanitary wastes to Linden-Roselle.
b. Oil water sewers.
c. Cooling and condenser water sewers.
d. Tank field sewer system.

The total refinery effluent averages 187 million gallons per day. Peak water pumpage occurs during the latter part of August when total process water use and cooling may reach 220 million gallons per day. These volumes are exclusive of sanitary wastes.

The refinery effluent is the discharge over No. 1 Dam which is located in the lower reaches of Morses Creek. This stream discharges to the Arthur Kill at the northeast corner of refinery property and approximately 2,200 feet north of the refinery intake.

8. Principal Processes:

The principal processes of the Bayway Refinery, exclusive of the Chemical Products Department, are:

Atmospheric Distillation
Vacuum Distillation
Visbreaking
Catalytic Cracking
Reforming

Polymerization

Alkylation

Superfractionation

Gas oil hydrofining

General treating

Hvy. Cat. Naph. Hydrofining.

WASTES CHARACTERISTICS

The amount of non-hydrocarbon constituents in the petroleum may be taken as a fairly good criterion of the extent of treatment required to produce marketable products. The principal impurities in petroleum include free sulfur, hydrogen sulfide, sulfur compounds, nitrogen, and oxygen. The asphaltic and resinous bodies which are present in various amounts in most crude are considered to be formed, in part, by the oxidation and polymerization of certain hydrocarbons in the crude oil. Process wastes from a petroleum refinery may be expected to contain various chemicals used in treatment of petroleum products, combined with the impurities referred to, together with oil in various stages of process. Many of these wastes are relatively small but their effects on the refinery effluent are accumulative.

The most offensive constituents in petroleum refinery wastes, from the standpoint of pollution, are believed to be phenols, mercaptans, nitrogen bases, naphthenic acids, and oil. With the exception of oil, these most offensive substances are normally concentrated in the wastes resulting from chemical treatment. The overhead receiver water from catalytic cracking units is a significant source of phenol.

Light distillate oils may contain H_2S, low molecular weight naphthenic acids, phenol compounds, mercaptans, and other sulfur compounds. Organic nitrogen compounds may be present in low concentrations. Heavy naphtha and heating oils are now treated by the hydrofining process. Hydrofining has replaced all acid treating, doctor sweetening, and lead sulfide-sulfur sweetening.

Emulsions formed in refining operations are predominantly oil-in-water emulsions or systems of oil dispersed in water, the water constituting the external or continuous phase. The barometric condensers on the two vacuum pipe stills have been replaced by surface condensers, thereby eliminating two major emulsion sources.

WASTES TREATMENT PRACTICE

Humble Oil and Refining Company has taken cognizance of the value of oil wasted through the sewers and the damage resulting from oil pollution. Effort has been made in recent years to minimize wasting of oil to the sewers. Design of oil refinery equipment has made possible retrieving valuable oil as near the source as possible. Prevention of the comingling of various process wastes, containing oil, aids materially in reducing the tendency for troublesome emulsions to form.

9. Oil-Water Separators:

The Bayway Refinery has two master oil-water separators, each serving different plant areas. In addition there are three intermittent flow-type separators serving the outlying tank field areas south of Morses Creek. One fixed baffle has been installed at the No. 1 Dam on Morses Creek to skim oil carried over in the separator effluents or inadvertently discharged to the condenser water sewer system.

The east oil-water separator is 300 feet long by 100 feet wide with an eight-foot water depth. This separator is divided into two channels, each with six compartments 50 feet square. Currently only half of this separator is in service at one time. The present flow was reported to be 9.9 MGD which gives a detention time of two hours and six minutes and an average velocity of 2.3 feet per minute. The east separator serves the area in which it is located, the principal sources including:

Atmospheric pipe stills;
Esso Research and Engineering Company;
Mechanical shops area;
White Oil Division;
Office buildings and laboratories of Bayway.

The west oil-water separator was placed in operation in 1940. It consists of a pre-separation flume 125 feet long and three settling channels each twenty feet wide by 138.5 feet long with a 8.25-foot water depth. One of these channels was out of service because of a damaged flight scraper. The west separator presently receives 7 MGD flow. Considering three channels in service, the 7 MGD flow gives a detention time of one hour and 57 minutes (including the pre-separator flume) and a velocity of flow of 1.4 feet per minute.

The pre-separator flume in the west separator is quite effective, removing up to 80 percent of the oil entering this unit. Oil skimmers in each separator are operated manually. Recovered oil is pumped to slop oil tanks for decantation and heat treatment. Records indicate water-free recovered oil varying between 400 and 600 barrels per day.

10. Spent Chemicals:

Concerted effort is made to keep spent chemicals out of the sewers and it was reported that spent cresylics were sold and that shipments amounted to 100,000 gallons per month. Other spent caustics are shipped far out to sea in transocean tankers. Spent acids are sold to a local chemical firm. H_2S gas is converted to sulfur by the same chemical company.

11. Analytical Results:

A Honeywell Effluent Monitor is located at the No. 1 Dam. This monitor continuously records dissolved oxygen, conductivity, temperature, and pH.

Samples for oil determination are routinely collected from the effluent at No. 1 Dam by refinery personnel. Oil results vary significantly from season to season. In general, effluent oil results obtained by the Bayway Refinery laboratory are higher than those reported by the control agencies. There appears to be a threefold variation in concentration of oil reported by the refinery laboratory. Considering a net concentration of 17 parts per million oil and a flow of 191 MGD, oil losses amount to

3,400 gallons per day (1957 refinery data).

Net phenol concentrations in the refinery effluent at No. 1 Dam likewise vary appreciably. Data from a 1962 survey indicated that a net concentration of phenol in the effluent was 2.5 parts per million, giving a daily phenol loss of 4,000 pounds.

Considering that the effluents from the two oil-water separators are diluted ten to one with condenser water, it appears that oil concentrations in the A.P.I. separators may be as high as 170 ppm.

WATER POLLUTION ABATEMENT PROGRAM

Attention was invited to the fact that salt water used at the Bayway Refinery complicated both analytical procedures and pollution abatement measures. It was estimated that over 95 percent of the flow through the oil-water separators originated in the Arthur Kill.

It was pointed out that from the design standpoint, the salt water cooling system was fully loaded during the peak summer periods. Accordingly, recent major increments of new cooling capacity have been provided as air fin installations. Substitution of the air fin installations avoids high capital cost of expanding the salt water pumping and distribution facilities.

The wastes control and water pollution abatement program at the Bayway Refinery is proceeding simultaneously along three lines. These are:

a. Progressive reduction in liquid volume.

b. In-plant improvements which reduce wastes.

c. Study of possible methods for treating residual wastes.

Decision as to treatment for residual wastes is dependent upon established water uses in the Arthur Kill and necessary protection of the bays into which the Kill discharges.

The Cities Service Oil Company Linden Refinery
Linden, N.J.

1. Organization:

The Cities Service Refinery is located at the eastern edge of Linden, New Jersey, between the New Jersey Turnpike and the Arthur Kill. The refinery property consists of some 240 acres, including a tank farm area located along the westerly portion of the New Jersey Turnpike in Linden. The installation, employing 150 people, was constructed in 1917 and completely rebuilt in 1958.

Mr. Joseph S. Baum, located in East Chicago, Indiana, is Waste Disposal Coordinator for the refinery. Mr. Robert G. Hand, Resident Chemist, along with two other chemists, is in full attendance at the refinery.

2. Products:

The Cities Service Oil Company Refinery at Linden is essentially an asphalt plant. Production is geared to continuous flow rather than batch operations. The principal products run at this plant are:

Asphalt - 70 percent of the crude;

300 end point gasoline;

400 end point mineral spirits or Stoddard solvents;

No. 2 fuel oil;

Light and heavy virgin gas oil -- sold as cracker feed stock.

3. Raw Materials:

Crude oil is received by tankers from Mexico and Venezuela. Panoco crude is obtained from the Gulf and Tia Juana crude is received from South America. The Gulf crude, because of quality, will soon be phased out at this plant. It is anticipated that only Venezuela crude will be handled in the future. These are essentially sour crudes, the sulfur concentration generally being in the range of

5.0 to 5.25 percent (total sulfur by weight). Salt concentration in the crude runs from 10 lbs. per thousand barrels for Venezuela crude to 125 lbs. per thousand barrels for Mexican crude.

Because of the nature of the plant -- asphalt production -- very few raw materials are used. The only significant import is caustic which is used to reduce sulfides. Small quantities of ammonia and amine are purchased for corrosion control.

4. Capacity:

This plant has the capacity for refining 14,000 barrels (42-gallon barrel) of crude oil per stream day. Normal wintertime operation is approximately 9,000 barrels per stream day. The peak rate is reached during the summer months when the demand for paving asphalt is high.

5. Operations:

Since this plant is designed for asphalt production, cracking of crudes and intermediates is avoided. Essentially, the plant utilizes straight steam distillation -- one atmospheric and one vacuum column. Vacuum is created on the vacuum still by Elliot Company type steam jets.

Operating temperatures are kept below 700°F in the atmospheric column and 800°F in the vacuum column so as to prevent cracking. Steam is supplied at the rate of 2,000 lbs. per hour to the vacuum still and at 2,800 lbs. per hour to the atmospheric column.

The plant operates 24 hours a day, 7 days a week, 11 months a year. The installation shuts down for one month during the wintertime for maintenance. Industrial asphalts for roofing are run year round and paving asphalts, used for roads, are run during the warmer months.

The tank farm is supplied by the Colonial Transcontinental Pipeline. This is a completely separate operation from the asphalt plant.

6. Water Supply:

Two sources of water are available, namely, Arthur Kill and the Elizabethtown Water Company. Elizabethtown water is used for drinking, sanitary purposes and steam production. A Zeolite softener is used to condition boiler feed water. The bulk of water for the refinery is pumped from the Arthur Kill and is used for cooling purposes. Approximately 0.36 million gallons per day of fresh water and 7.2 million gallons per day of salt water are used by the plant. The quality of the Arthur Kill water presently satisfies the needs of the plant. No problems have been encountered with corrosion or clogging as a result of these waters being used for cooling.

A chlorination system, which was originally provided, has been discontinued since experience at the plant has shown that this treatment is not necessary. Cooling water from the Arthur Kill is handled by one electric-driven, 4,000-gallon-per-minute pump, and one 800-gallon-per-minute unit tied in with the process blending equipment. A steam operated 4,000-gallon-per-minute unit has been provided for standby operation. This unit is used approximately once per week while the screens of the electric driven unit are cleaned.

7. Sewerage:

All sanitary wastes from the facility are handled in a septic tank and tile field system. All cooling waters and process waters are handled in one sewer system. Storm runoff from the tank fields in the immediate area of the refinery also discharges to the same sewer system. To prevent purging the tank fields are valved to permit bleeding of the runoff into the sewer.

The total refinery effluent averages 5,000 to 6,000 gallons per minute, exclusive of the sanitary wastes volume. It is discharged through three 12" diameter pipelines located in the Arthur Kill bulkhead. These discharges are located at the northeast corner of the refinery property and approximately 1,500 feet from the raw water intake.

8. Principal Processes:

Principal processes at the Cities Service Refinery are:

Atmospheric distillation;

Vacuum distillation;

Treating (gasoline sweetening, Bender Process);

Oxidation;

Cutback blending.

WASTES CHARACTERISTICS

Generally speaking, the amount of non-hydrocarbon constituents in the petroleum may be taken as a fairly good criterion of the extent of treatment required to produce marketable products. The principal impurities in petroleum include free sulfur, hydrogen sulfide, sulfur compounds, nitrogen, and oxygen. The asphaltic and resinous bodies which are present in various amounts in most crude are considered to be formed in part, by the oxidation and polymerization of certain hydrocarbons in crude oil. Process wastes from a petroleum refinery may be expected to contain various chemicals used in treatment of petroleum products, combined with the impurities referred to, together with oil in various stages of process. Many of these wastes are relatively small but their effects on the refinery effluent are accumulative.

The most offensive constituents in refinery wastes, from the standpoint of pollution, are believed to be phenols, mercaptans, nitrogen bases, naphthenic acids and oil. With the exception of oil, these most offensive substances are normally concentrated in the wastes resulting from chemical treatment. The overhead receiver water from catalytic cracking units is a significant source of phenol.

However, the foregoing statements refer to petroleum refineries processing full range crude oils and employing cracking operations.

The operation of this asphalt plant and the products formed during processing are contrary to the general ideas stated above. This refinery, being an asphalt plant, is operated to reduce the low gravity crudes to a heavy tar called asphalt. To do this, cracking conditions are avoided. As a result of this type of operation, there are no unusual products formed during processing. That is, only minor quantities of phenols and ammonia are formed in the refinery.

Although the crude process is high in sulfur content, the sulfur remains in the asphalt and thus enhances the quality of this product. Tests indicate that there is 5.2 percent sulfur by weight in the finished product.

Emulsions formed in refining operations are predominantly oil-in-water emulsions or systems of oil dispersed in water, the water constituting the external or continuous phase. Emulson problems have reportedly been reduced by keeping the caustic segregated from other waste streams. Approximately 4,000 gallons of waste caustic is sold to a vendor every six weeks. This waste caustic is from the Bender Treater, which sweetens gasolines by converting mercaptans to disulfides, which are soluble in oil.

WASTE TREATMENT PRACTICE

Cities Service Oil Company has taken cognizance of the value of oil wasted through the sewers and the damage resulting from oil pollution. In 1958 a completely new treatment system was installed and in 1960 the oil seperator was modified. Plans are now being prepared for installing flow metering and sampling equipment.

Paul DeFalco

9. Oil-Water Separators:

The Cities Service Oil Company has one A.P.I. oil-water separator located above grade. It is divided into three parallel sections, each approximately 20 feet wide by 156 feet long and has an approximate water depth of 7 feet. Each section has three settling compartments -- 22-foot long inlet chamber; 66-foot long primary basin; 68-foot long secondary basin. Every compartment contains its own sludge collecting and skimming mechanism, sump, and auger type sludge conveyor.

In 1960 the oil-water separators were remodeled. Reaction jets were installed on each of the five 12-inch diameter inlet pipes in the primary and secondary basins of all separators. Essentially, these jets consist of a curved deflector plate, approximately one inch larger than the diameter of the pipe, installed three inches away from the inlet pipe. As wastes enter the tank through the pipes they deflect off the plates and back on to the tank wall, thus creating laminar flow at the tank inlet.

Skimmings from the separators are pumped to two small circular settling tanks where further separation is accomplished. The water from these settling tanks is returned to the settling pit (old separator) for further treatment and decanted oil is pumped to the slop tanks.

Sludge from the separators (flights operated approximately twice per 24-hour day, and solids removed once per week) is pumped to the plant's settling pit (old separator), which is now used only to provide additional settling time. Skimmings from the settling pit (old separator) are pumped to a slop tank. Approximately once every six weeks a contractor is brought in to remove the settled sludge.

There is presently no flow indicating or recording device at the plant. Flow records are based on raw water pumpage. It is estimated that wastes flow is approximately 5,000 gallons per minute. An additional 1,000 gallons per minute is added during wet weather flow.

10. Spent Chemicals:

Spent caustics are collected in a tank truck and sold to a vendor.

11. Analytical Results:

Oil samples are routinely collected from all three discharge pipes by refinery personnel. Oil results vary slightly from season to season. Data for the past four years indicate that the oil concentration averages approximately 15 parts per million with peaks of 50 parts per million. A noticeable increase in oil recovery from an average of 50 parts per million down to 15 parts per million resulted after 1960, when the reaction jets were installed in the separators. The present oil load to the Arthur Kill is approximately 900 lbs. per day.

During the past two years refinery results indicate that the phenol concentration in the effluent is less than 40 parts per billion, which is equivalent to 2.4 lbs. per day.

BOD's of the effluent are run routinely, once or twice per month, on each of the separator effluents. It appears, based on Cities Service data, that the plant is contributing approximately 20 parts per million or 1,200 lbs. of BOD per day to the Arthur Kill.

WATER POLLUTION ABATEMENT PROGRAM

Attention was invited to the fact that salt water, used at the Cities Service refinery, complicated both analytical procedures and pollution abatement measures. It is estimated that during dry weather over 95 percent of the flow through the oil-water separators is brackish.

The waste control and water pollution abatement program at the refinery presently calls for installing an automatic effluent sampler, the combining of all three effluent discharges into one common line, and the installation of a Parshall flume.

Hess Oil & Chemical Company, Port Reading Refinery

Port Reading, N.J.

1. Organization:

The Hess Oil Refinery, located in Port Reading, New Jersey, directly on the Arthur Kill, consists of approximately 65 acres including tank farm area. The plant layout is compact with little open space in the process area.

The refinery was constructed in 1958 and expanded in 1961. The plant is automated to the maximum possible and employs a figure well below the national average of 11 persons per 1,000 barrels of crude per day. Published material describing this refinery can be found in the annual Oil and Gas Journal Survey.

2. Products:

The Port Reading Refinery produces only petroleum products. Petrochemical production by Hess Oil Company is accomplished at the company's Corpus Christi, Texas, refinery. The products of the Port Reading Refinery are:

Pitch (residual);

Home heating oil #2;

Jet fuel;

Gasoline;

LPG.

The only plant by-product is sulfur from the sulfur recovery process.

3. Raw Materials:

The refinery is designed to process sweet crude only and efforts to utilize sour crude generally have been unsuccessful. More than 60 percent of the raw materials are U.S. coastal crudes with a sulfur content of 0.35 percent or less. Additional sweet crude is obtained from Venezuela fields.

Processing chemicals used are limited to caustic, acid, and organic inhibitors.

4. Capacity:

The refinery has a design capacity of 65,000 barrels of crude oil per day. Under normal operations plant capacity can be slightly higher than this figure. On the date of the Public Health Service visit the plant was running at capacity.

5. Operations:

The major process operations are as follows:

Crude distillation;

Reforming (platinum catalyst);

Desulfurization (cobalt molybdenum catalyst);

Fluid catalytic cracking;

Gas recovery for LPG manufacture;

Alkylation (sulfuric acid catalyst in closed system);

Caustic scrubbing (gasoline and #2 fuel oil).

Spent caustic is recovered and sold or dumped at sea. Used sulfuric acid is recovered and returned to the acid vendor for regeneration.

The plant operates continuously and has a 95 percent service factor based on a 24-hour day, 365-day year.

6. Water Supply:

Water is obtained from two sources, the Middlesex Water Company and the Arthur Kill.

Arthur Kill water is utilized only for fire and wash-down processes; use is estimated at 50 to 100 gpm. A 2,000 gpm pump operates approximately two to eight hours per day to maintain pressure in the fire and wash-down lines.

The bulk of the water utilized in the refinery is purchased from Middlesex Water Company. Approximately

60 gpm is utilized for drinking and sanitary purposes, and an additional 80 to 120 gpm is used for process water. The plant utilizes a closed cooling water circuit and requires 800 to 1,000 gpm of Middlesex water for make-up purposes. The only treatment given water is in the cooling system. The refinery has two towers operated by other companies, one utilizing a mixed chromate-phosphate treatment, the second a chromate. An additional 300 gpm is purchased from Middlesex Water Company for use in the company's steam plant. Company records indicate an average of 1,345 gpm of water is purchased from the Middlesex Water Company.

7. Sewerage:

There are three separate sewer systems within the refinery as follows:

a. Sanitary wastes to the Sewaren Municipal Treatment Plant;
b. Storm water drains;
c. Oily water sewers.

Oily water sewerage is passed through an API separator to a holding pond; storm water drains discharge directly to the holding pond. From the holding pond, effluent is pumped to the Arthur Kill.

8. Other Utilities:

Electricity is purchased from the Public Service Sewaren Generating Plant adjacent to the refinery. The Public Service Plant purchases "residual" fuel oil from the refinery.

The refinery operates its own steam plant equipped with 4 Titusville boilers and operating at about 260 lbs. pressure head. Approximately 300 gallons per minute of water is purchased from Middlesex Water Company for make-up in the steam plant.

WASTES CHARACTERISTICS

The amount of non-hydrocarbon constituents in petroleum may be taken as a fairly good criterion of the treatment required to produce marketable products. The principal impurities in petroleum include free sulfur, hydrogen sulfide, other sulfur compounds, nitrogen and oxygen. The asphaltic and resinous bodies which are present in various amounts in most crude are formed in part by the oxidation and polymerization of certain hydrogen compounds in the crude. Petroleum refinery wastes may be expected to contain various chemicals used in the treatment of petroleum products as well as the impurities referred to above and oil in various forms. Many of these wastes are relatively small but their effects on the refinery effluent characteristics are accumulative.

The most offensive constituents in petroleum refinery wastes, from the standpoint of water pollution, are believed to be phenols, mercaptans, nitrogen bases, naphthanic acids, and oil. With the exception of oil these substances are normally concentrated in the wastes resulting from chemical treatment. For example, the overhead receiver water from catalytic cracking units is a significant source of phenol.

Light distillate oils may contain hydrogen sulfide, low molecular weight naphthenic acids, phenol compounds, mercaptans, and other sulfur compounds. Organic nitrogen compounds may be present in low concentrations. Emulsions formed in refining operations are predominantly oil and water with the water constituting the external or continuous phase.

WASTES TREATMENT PRACTICE

Hess Oil & Chemical Company in the design and construction of the Port Reading Refinery has taken cognizance of the value of oil which could be lost through sewers as well as possible water pollution from oil and other pollutants. In addition to incorporating necessary treatment facilities for oil recovery and pollution abatement, the company followed the most modern available design considerations so as to prevent comingling of various wastes which might result in troublesome emulsions.

9. Waste Sources and Treatment:

The major source of phenol is the overhead receiver water from the cat cracker which averages 100 mg/l phenol and amounts to 25 to 40 gpm in volume. On an experimental basis the refinery has obtained 90 percent phenol reduction from this source by utilizing the receiver water in desalting processing. Before attempting the desalting as a reduction means, the plant waste stream entering the API separator averaged 1 to 10 mg/l of phenol. No data are available since the desalting experiment was begun.

The other major phenol source is draw-off from the tank fields. This liquid waste is discharged directly to the holding pond and would result in a peaking effect of phenols when draw-off is accomplished.

Sulfide and hydrogen-sulfide removal is accomplished by a UOP sulfide stripper using flue gas and steam. This unit treats the overhead receiver water from the cat cracker and caustic wash from the alkylation process.

The stripper has shown good sulfide and hydrogen-sulfide removal but has little effect on phenol concentrations.

An analysis by an outside firm of the overhead receiver water which was sampled in November 1964 showed the following results:

ITEM	CONC., mg/l
Phenol	76
COD	100
pH	7.9
Alk M.O.	1900 as $CaCO_3$
Total Solids	4
H_2S as S	1210 (.121%)
Mercaptan as S	10
Color, APHA Pt-Co	45
Turbidity	Clear
Ammonia as NH_3	7000 (0.70%)
Chloride as Cl	13
Sulfate as SO_4	8
Cyanide, ppm CN+CNS	4.3
Oil	Not run

The waste treatment system consists of an API oil separator followed by a holding pond. The API separator consists of two parallel bays each 13' wide by 106' long (effective settling length) and a mean liquid depth of 5'. Average flow to the separators is 250 gpm. Both bays are equipped with flight scrapers, skimmers and baffled inlets. The bays are utilized alternately rather than in parallel so as to permit cleaning one bay while the second is in use. Slop oil from the separators runs from 158 to 277 barrels per day with 30 percent to 50 percent water. This is held in slop tanks until sufficient volume is available at which time it is pumped to the crude storage tanks. In addition to a very small amount of slop oil from the plant, the separator also receives pumpage from various customers and occasional sludge from the tank farms when these are cleaned. No routine check is made on the separator operating efficiency. As sludge accumulates in the separator it is pumped and trucked away under contract. A visual inspection was made of the separator operation. A heavy passage of oil through the separator was noted due to a build-up of sludge in the separator tanks. From the separator, effluent flows by gravity to a holding pond approximately 300' long by 200' wide. The holding pond effluent passes through four pairs of hay-filled screens. These screens are generally cleaned monthly depending upon the amount of head loss noted. From the holding pond, plant effluent is pumped to a submerged discharge to the Arthur Kill. In addition to the separator line the holding pond also receives other discharge lines including storm water drains and tank farm drainage. Inspection of the holding pond showed a considerable amount of oil present with some signs of the formation of sludge deposits in the pond, probably attributable to excess oil from the separators.

Visual examination of the pump effluent discharge from the holding pond indicated no readily apparent oil slick on the Arthur Kill from the submerged outlet.

10. Analytical Results:

The refinery performs limited analyses of the final effluent from the holding pond. Grab samples are taken every few weeks and sent for analysis by an outside firm. Hess Oil does check for sulfide and pH. Analytical results indicated the following ranges:

Phenol -- 1 to 10 mg/l;

COD -- several hundred;

sulfide -- 0;

chromate -- 0;

chloroform extractables -- 22 to 68 mg/l
(but one sample 121 mg/l).

WATER POLLUTION ABATEMENT PROGRAM

The Hess Oil & Chemical Company refinery is continuing its efforts in waste control and water pollution abatement. A pilot plant study is under consideration to develop secondary treatment for phenols in drainage from the tank farm. The company plans to continue its work in the reduction of phenol from the cat cracker overhead receiver water by the use of this water in the desalting process.

California Oil Company
Perth Amboy, New Jersey

1. Organization:

This refinery is operated by the California Oil Company, which is a wholly owned subsidiary of the Standard Oil Company of California. Full ownership of the refinery was acquired in 1948. The California Oil Company serves 12 Eastern States from Maine to Virginia.

This refinery has been completely rebuilt in recent years. Most of the old process equipment has been dismantled. The refinery is located at the north edge of

Perth Amboy some 2 miles upstream from the point where the Arthur Kill enters Raritan Bay.

The Standard Oil Company of California is represented by Mr. John Easthagen on the American Petroleum Institute Committee on Disposal of Refinery Wastes. Mr. Easthagen serves as consultant to all refineries within the company on matters pertaining to liquid waste disposal.

2. Products:

Principal products run at the refinery are:

a. Aviation gasoline;
b. motor gasoline;
c. liquefied petroleum gas (LPG);
d. solvents (hexanes, heptanes, etc.);
e. kerosene;
f. #2 fuel oil;
g. #4 fuel oil;
h. #6 fuel oil;
i. paving asphalts;
j. asphalt cutbacks.

Refined products are shipped to various distribution points and to consumers via tank ship, pipeline, barge and tank truck.

3. Raw Materials:

This refinery was originally intended to process principally Arabian crude. Crude is presently received principally from Arabia, Venezuela, and the Gulf Coast area. Crude oil is received at the refinery exclusively via tank ship.

The sulfur content of the crude oil averages about 1 to 2 percent by weight. It was pointed out that much of the sulfur in the crude oil ends up in asphalt residual.

The salt content of the crude oil averages about 15 pounds per 1,000 barrels. An electrostatic system is employed in desalting.

Crude oil is the principal raw material. Other raw materials include ammonia for corrosion control and caustic for chemical treatment of certain products.

4. Capacity:

This refinery is running about 70,000 barrels (42-gallon barrels) of crude oil per calendar day. This would approximate 75,000 barrels per stream day. The Standard Oil Company of Kentucky, another subsidiary of the Standard Oil Company of California, has recently built a petroleum refinery in the State of Mississippi. There are no plans for expanding the refinery at Perth Amboy.

A phthalic anhydride plant was built in 1962. Phthalic anhydride is the only chemical manufactured. There are no immediate plans for petro chemical expansion.

5. Operations:

The crude units, cracking unit, and auxiliary equipment operate continuously. Other refining and treatment processes are likewise continuous. The refinery operations should be considered as being on a 24-hour day, 7-day week basis.

6. Employees:

There is a total of 900 employees, including office personnel and operating staff.

7. Water Supply:

There are three sources of water supply, namely, Arthur Kill, two company wells, and the Perth Amboy public water supply.

A pump station located on the Arthur Kill draws salt water from this source at a rate of about 30,500 gallons per minute for circulation as cooling water to various units. In order to reduce salt water intake and effluent volume, two salt water cooling towers are in operation for cooling some 20,000 gallons per minute of salt water for reuse as cooling water in various process units. There is no chemical treatment of the Arthur Kill water.

Production of the two company wells is restricted by the State Water Policy Board. These wells were reported to average 325 gpm. City water averages 1.4 mgd. City water goes to boiler feed make-up and limited process use. The attached diagram of process water system depicts water use within the refinery. Arthur Kill water was reported satisfactory for refinery use. Trouble was reported recently from a large accumulation of plastic bags on the screen at the river intake.

8. Sewerage:

There are four separate sewer systems designated as:

a. Sanitary sewer;
b. storm sewer;
c. clean water sewer;
d. oily water sewer.

These systems are indicated on the attached diagram which is designated "Effluent Water Treatment Facilities, California Oil Company." Sanitary wastes are discharged to the Perth Amboy sewerage system for treatment. Treated refinery process waste waters and cooling waters are discharged to Woodbridge Creek, which is tributary to the Arthur Kill.

REFINERY PROCESSES

The principal refining processes are shown on the attached flow diagram. The crude units include two vacuum pipe stills in which the vacuum is created by barometric condensers. The catalytic cracking unit is a Houdriflow type and makes use of a bead catalyst.

Light hydrocarbon gases are conveyed to the Anlin Company, adjacent to the refinery, for removal and recovery of sulfur. The desulfurized gas is returned to the refinery for production of steam and power. Liquefied petroleum gas is desulfurized by fractionation and caustic scrubbing and is dried by an alumina absorbent. Gasoline is chemically treated to convert mercaptans to disulfides. Entrained caustic containing water from certain intermediate gasoline storage tanks is combined with spent caustic for disposal at sea. Kerosene is desulfurized by the Perco process which makes use of a solid bed of cupric chloride.

WASTE WATER TREATMENT

Concerted effort is made to keep spent chemicals out of the refinery sewers. These concentrated wastes are disposed of in the ocean, being transported by oil tankers returning to Arabia for crude oil. California Oil Company, in recent years, has spent over 1 million dollars on waste treatment facilities at the Perth Amboy refinery.

9. Oil-Water Separators:

It will be apparent from the foregoing that the principal liquid waste problem at this refinery is the separation of oil products from water. Considerable thought has been given to oil-water separation and a rather flexible system has been devised. This system is shown diagrammatically on the attached sketch designated "Effluent Water Treatment Facilities."

These oil-water separators are described in detail in material submitted by the New Jersey Department of Health. This material provides information on sources of wastes, equipment description, and operation. It was reported that reduction in water use had reduced flow to #2 API separator from 18,000 gpm to 12,000 gpm. Likewise, flow to #3 separator is presently 4,000 gpm instead of 6,000 gpm as shown on the diagram.

10. Operation of Separators:

There were some irregularities in the operation of these oil-water separators at the time of our visit. Mention is made of these observations as a matter of record. The north compartment of the west half of the #2 separator was inoperative. It was estimated that 75 percent of the flow reaching the #2 separator was being diverted through the east half of the unit. There was very little oil reaching the #2 separator and it would appear that one-half of the #2 separator might provide adequate capacity for this particular flow.

The #3 oil-water separator appeared to be overloaded, both hydraulically and on the basis of accumulated oil. Efficiency of the #3 separator was believed influenced by pumping water from the adjacent oil bin to the separator inlet by means of an ejector. Handling of oil recovered by the #3 separator was complicated by the absence of an oil pump which was out of service for maintenance. Each compartment of the #3 separator contained a significant accumulation of oil and there was evidence of oil in the effluent from this unit.

There was substantial accumulation of oil floating on the south half of the 13-acre settling basin (lagoon). Plans are under way to provide a skimmer for oil accumulating in the first half of this settling basin. Oil accumulated on the surface of this settling basin drains to the surge pond from which it is pumped to the #4 separator inlet. This surge pond pump was operating at the time of our visit.

Based on observations at the time of our visit, it appeared that the #2 separator was operating under capacity and the #3 separator was overloaded. Short-time efficiency studies of these separators will either confirm or disprove this theory. It was reported that slop oil recovery averaged 200 barrels per day water-free oil. Sludge pumped from the oil-water separators is disposed of in a pond on refinery property. Maleic acid from phthalic anhydride production is incinerated. See comment below by California Oil Company.

> "Comment is made regarding irregularities in the operation of No. 2 and 3 separators at the time of your visit. It was noted that the north compartment of the west half of No. 2 separator was inoperative. This was due to a routine bin cleaning operation. However, as was noted, effluent water was clear, indicating that the separator had sufficient capacity to absorb the cleaning operation without unduly reducing separating efficiency.
>
> "It was also noted that effluent water from No. 3 separator contained traces of oil. This was due to mechanical failure of a pump which lifts

"influent oily water from a collection bin to the separator. An eductor was being used temporarily for this service, which caused excessive agitation of the oily influent water and made oil separation in the separator less efficient than normal. However, effluent from this separator goes to a large settling and oxidation basin before discharge to Woodbridge Creek. The basin effluent was observed to be visibly free of oil during your visit, further illustrating the efficiency and value of this facility as a final clean-up for our oily water stream. The pump in question on No. 3 separator is now back in service and the separator is back to normal and satisfactory operation."

11. Pollution Parameters:

Effluents from this refinery are routinely checked for:

a. Oil - total and volatile;
b. biochemical oxygen demand;
c. phenols;
d. sulfides;
e. pH.

A pump has been installed for manual sample collection within the outlet from the settling basin to Woodbridge

Creek. Samples are collected at this point daily and analyzed for sulfides and pH. Sulfides normally run less than 0.1 ppm. All five determinations listed above are run at least once a month.

Based on available data, it was estimated that oil losses from this refinery approximated 270 gallons per day. Likewise, it was estimated that phenol losses should average 25 pounds per day.

Progress in pollution abatement by this refinery is evidenced by the reduction in BOD of the effluents. This improvement is shown in the table designated "Biochemical Oxygen Demand, Effluent Process Water, California Oil Company," dated May 19, 1965.

The American Agricultural Chemical Company

Carteret, New Jersey

1. Organization:

The American Agricultural Chemical Company is solely owned by Continental Oil. It operates 35 plants extending from the eastern seaboard into Kansas, with the home office at 100 Church Street, New York, New York. The fertilizer plant has operated at this location in Carteret since around 1890 and the American Agricultural Chemical Company has been operating here from the turn of the century. As far as classification of chemical industry is concerned there are two distinct operations on the premises. One set of facilities is devoted to the manufacture of chemical fertilizers and the other set of facilities is devoted to production of chemical phosphates. The plant is located in the northern part of Carteret, New Jersey, abutting the Arthur Kill.

2. Products:

The chemical fertilizer facilities produce a complete line of mixed chemical fertilizers and a by-product, ammonia silicofluoride.

The chemical phosphate facilities produce phosphorus pentasulfide and sesquisulfide, sodium tripolyphosphate, and tetrasodiumphyrophosphate, di- and trisodium phosphate, and phosphoric acid.

3. Raw Materials:

The raw materials for the chemical fertilizer operations are ammonia solutions, triple superphosphate, potash, phosphate rock or phosphorite, anhydrous ammonia, sulfur, and waste organic material such as hair, wool, fur and leather scraps.

The raw materials for the chemical phosphate operations are elemental phosphorus, soda ash, and caustic.

4. Capacity:

The production of these facilities is highly variable and the capacity is considered to be confidential information.

5. Operations:

The usual schedule of operations for the various processes are indicated on the individual flow charts which accompany this report.

6. Employees:

The employment at these facilities varies from 200 to 300 with a normal employment of 240.

7. Water Supply:

Fresh water is purchased from the Middlesex Water Company and sea water is pumped from the Arthur Kill. The water use in the various processes is indicated on the individual flow charts.

8. Sewerage:

All sanitary sewage and some waste process water as indicated on the individual flow charts is discharged to the municipal sewer system. Other waste waters as indicated on the individual flow charts are discharged to the Arthur Kill. There are three main outlets to the Arthur Kill. One of these, bearing all wastes from operations other than the sulfuric acid plant, is discharged to the Arthur Kill in the vicinity of the south end of the dock. The waste waters from the sulfuric acid plant are discharged to a natural watercourse at the south edge of the property. A third line bearing wastes from the power plant and runoff from the land disposal area discharges to the Arthur Kill at the north edge of the property. A storm sewer discharges to the Arthur Kill underneath the dock and it is reported that there are not any process wastes in this pipe.

9. Outline of Processes:

In the fertilizer production, sulfuric acid is produced from the burning of elemental sulfur in the chamber process. This acid is used to produce superphosphate fertilizer from phosphate rock. The organic raw material is used in the agrinite process to produce a material for the mixed fertilizers. In the production of mixed fertilizers the base material is mixed dry and charged to the TVA ammoniator where it is mixed with water, ammonia solutions, and sulfuric or phosphoric acid. This mixture is dried, screened and cooled to produce various grades of mixed fertilizers.

The by-product ammonia silicofluoride is produced from anhydrous ammonia and waste hydrofluosilicic acid from the production of superphosphate.

In the production of chemical phosphates, phosphoric acid is produced from the combustion of elemental phosphorus. The phosphates are produced from phosphoric acid, soda ash, and caustic soda, while the phosphorous sulfides are produced from elemental phosphorus and elemental sulfur, as indicated on the individual flow charts.

SOURCES OF WASTE

10. Ammonia Silicofluoride Process:

There are two sources of wastes in this process, one liquid and one solid. A vacuum is pulled on the evaporator in this process by means of a jet ejector and the exhaust steam is cooled with approximately 300 gallons per minute of salt water. There is a potential source of pollution in this operation that the ammonia silicofluoride solution may be entrained in the cooling water. Based on the experience at other plants the local management does not believe that they are adding fluoride to the cooling water, but is unable to analyze for this material in the presence of other halides which are already present in sea water. When the fluosilicic acid is filtered; silica is removed as filter cake and it is estimated that approximately 1/10 of 1 percent of fluosilicic acid is lost with the cake. The cake is disposed of on ground to the north of the plant property. There undoubtedly is some surface runoff from this disposal area.

11. Phosphoric Acid Process:

In the existing phosphoric plant phosphoric acid leaks from the equipment into the circulating cooling water. This acid is neutralized with caustic in order to control the pH in the circulating water system. The slime in the cooling tower is controlled with chrome salts. The blowdown from the cooling tower amounts to a flow of approximately 25 gallons per minute and, of course, contains the concentrated chrome salts and phosphates.

12. Phosphate Crystallizer:

In the production of the sodium phosphates the crystallizer is operated under vacuum which is maintained by a jet ejector and the steam from the ejector is condensed with salt water flowing at about 300 gallons per minute.

There is a potential water pollution here if there should be entrainment from the crystallizer. Management reports that they make spot checks on this effluent for phosphates and entrainment have not been found.

13. Runoff:

The fertilizer operations at this facility are essentially dry operations and there is a good deal of dust about the premises, both on the roofs and ground surfaces. Obviously, in case of rainfall some of this material can be carried along with the surface runoff. The magnitude of this source of pollution with nitrogen and phosphorus is not known.

14. Ship Unloading

Approximately six vessels per year are unloaded at the plant docks. Such material as potash, phosphate rock, and triple superphosphate are received by ship. The material is unloaded from the ship by means of buckets and small cars. Occasionally there is some spillage from the cars if they are loaded too full, but this can be controlled. Wind at the time of unloading blows some of the material onto the dock and into the Arthur Kill. This may be on the order of six tons per ship load of material. The quantity of the material cannot be measured by difference in shipped and received weights.

WASTE CONTROL

15. Superphosphate Process:

At the time of this survey the dust from the grinding of rock was being settled and then scrubbed with wastewater going to the Arthur Kill. During 1966, a bag collector is to be installed and the wastewater will be eliminated.

Hydrofluosilicic acid is recovered from the acidulation of the phosphate rock.

The off gas from the present scrubber for the recovery of hydrofluosilicic acid is to be treated in a Venturi scrubber and the water will be used in the present scrubber.

16. Granular Mixed Fertilizer Process:

During 1966, several improvements for better air pollution control are to be made in the fertilizer plant.

The vent gases from the dryer are to be discharged to a cyclone instead of the dry bag dust collector and the solids returned to the mixer. The vent gases from the ammoniator and the new cyclone are to be discharged to a

Venturi scrubber and the wash water returned to the ammoniator.

The screens and the cooler are to be vented to a dry bag dust collector, eliminating the cyclone for the cooler.

17. Phosphoric Acid Process:

The existing acid plant leaks acid to the recirculating water system which bleeds to waste. The entire phosphoric acid plant is being replaced.

18. Sodium Phosphates Process:

All of the recirculating water on the scrubber is bled back to process.

19. Poly Phosphates Process:

The wastewater from the scrubber is fed to the mixer.

The city water in the cooling screw is not exposed to process material. (Flow diagrams of all processes have been supplied by the company.)

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E. I. du Pont de Nemours & Company, Inc., Graselli Plant
Linden, New Jersey

1. Organization:

This industrial complex located on 100 acres adjacent to the Arthur Kill in Linden, New Jersey, was obtained by du Pont in 1928. The plant, which began operation in 1884, was originally owned by Standard Chemical. Approximately 450 people are employed at this location.

2. Products:

List of Finished Products

Aluminum Chloride	Salt Cake
Aluminum Sulfate, I.F.	Sodium Bisulfite Solution
Anisole Technical	Sodium Silicate
Aqua Ammonia	Sodium Styrene Sulfonate
Chlorosulfonic Acid	Sodium Thiosulfate
Hydrochloric Acid	Strontium Nitrate
Methoxychlor	Sulfamic Acid
Nitric Acid	Weed & Brush Killer
Reagent Ammonium Hydroxide	Ammonium Sulfamate
Reagent Nitric Acid	Flame Retardants
Reagent Sulfuric Acid	Sulfuric Acid

Sulfur Trioxide

Dimethyl Hydroxy Amine

Dimethyl Sulfate

3. Raw Materials:

List of Raw Materials:

Acetic Acid
Aluminum Trichloride
Ammonia Anhydrous
Ammonium Phosphate Di-
Ammonium Sulfamate
Ammonium Sulfate
Boric Acid
Bromine
Carbon Bisulfide
Caustic Soda
Celestite Ore
Chloral
Chlorine Liquid
Dicyandiamide
Ethylene Diamine
Heptane
Hydrochloric Acid
Hydrogen Peroxide
Lime Chemical
Methylene Chloride
Nitric Acid
Phenol
Salt (NaCl)
Sand
Soda Ash
Sodium Bichromate
Sodium Bisulfite
Sodium Nitrite
Sodium Thiosulfate
Strontium Carbonate
Styrene
Sulfamic Acid
Sulfur
Sulfuric Acid
Urea

4. Capacity:

Plant outputs are considered confidential.

5. Operations:

The Grasselli complex is divided into ten separate manufacturing areas:

1) Organic Area: Manufacture of miscellaneous organic intermediates and agricultural products. Several operations are seasonal and operate 8 to 12 weeks per year. All operations produce 24 hours per day, 7 days per week, when on stream. Products include the organics indicated on our product list. This area contributes all the miscellaneous organic waste listed including the phenolics. It is a minor contributor (5 percent) to the total acidity and nitrite-nitrate nitrogen; a 10-15 percent contributor to the ammonia + organic nitrogen.

2) Strontium Area: Manufacture of strontium nitrate and strontium carbonate. Operations are 24 hours per day, 7 days per week. This area produces the largest portion of the nitrite-nitrate nitrogen waste; however, the ratio of nitrate to nitrite is 99 to 1, respectively.

3) Hydrochloric Area: Manufacture of various grades of hydrochloric acid and salt cake. Operations are continuous. Acidic wastes are neutralized.

4) Amine Area: Do not manufacture amines; strictly an area for the preparation of amine solutions of various strengths by the dilution of anyhdrous amines with water. Operations are 1 shift per day, 5 days per week. A fair contributor (20%) to the ammonia + organic nitrogen waste.

5) Central Area: Manufacture of sodium thiosulfate which operates 24 hours per day, 5 days per week; aluminum sulfate which operates 24 hours per day, 7 days per week; and aluminum chloride which operates 16 hours per day, 5 days per week. The former contributes the reducing inorganic salt waste, while the latter two contribute a negligible amount of acidic waste.

6) Sulfamic Area: Manufacture of sulfamic acid and its associate products. The latter includes ammonium sulfamate, the flame retardants, and the weed-brush killer. The area is in operation 24 hours per day, 7 days per week. It is a major contributor to the total acidity and ammonia + organic nitrogen categories.

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7) Silicate Area: Manufacture of glass and various grades of sodium silicate solutions. Operations are 24 hours per day, 7 days per week. A negligible contributor to the waste picture.

8) CP Reagent Area: Manufacture and package various reagent grade commodities. These include reagent grade ammonium hydroxide, nitric acid, sulfuric acid and hydrochloric acid. The area operations section is producing 24 hours per day, 7 days per week. The area is a very minor contributor to the waste profile.

9) CSA - SO3 Area: Manufacture of chlorosulfonic acid and sulfur trioxide. Operations are 24 hours per day, 7 days per week. This area is a significant contributor to the total acidity category.

10) Sulfuric Area: Manufacture of various strengths of sulfuric acid. Operations are 24 hours per day, 7 days per week. This area contributes a very minor quantity of acidic waste to the stream pollution picture.

OPERATIONS

AREA	AREA PRODUCTS	Hours/Day	Days/Week	TYPE OF WASTE	QUANTITY
ORGANIC	Miscellaneous Organic	24 Hrs.	7 Days	Miscellaneous organic	100%
	intermediates and agri-	Some seasonal		Phenolics	100%
	cultural products.	operations.		Total Acidity-Nitrogen	Minor (< 5%)
STRONTIUM	Strontium Nitrate Strontium Carbonate	24 Hrs.	7 Days	Nitrite - Nitrate Nitrogen	Major portion but 99 to 1 ratio NO_3^- to NO_2^-
HYDROCHLORIC	Hydrochloric Acid and Salt Cake	24 Hrs.	7 Days	Acidic-Neutralized	Minor
AMINE	Amine Solutions	8 Hrs.	5 Days	Ammonia + Organic N	20% Range
CENTRAL	Sodium Thiosulfate	24 Hrs.	5 Days	Reducing Inorganic salts	100%
	Aluminum Sulfate	24 Hrs.	7 Days	Acidity	Negligible
	Aluminum Chloride	16 Hrs.	5 Days	Acidity	Negligible
SULFAMIC	Sulfamic Acid and Associate	24 Hrs.	7 Days	Acidity as $CaCo_3$	Major (70%)
	Products	24 Hrs.	7 Days	Ammonia + Organic N	Major (80%)
SILICATE	Glass and Sodium Silicate Solutions	24 Hrs.	7 Days	Silicates	Negligible
CP - REAGENT	Reagent Grade Acid	24 Hrs.	7 Days	Acidity as $CaCo_3$	Minor (<5%)
	and Ammonium Hydroxide			Ammonia N	Negligible
CSA - So_3	Chlorosulfonic Acid and Sulfur Trioxide	24 Hrs.	7 Days	Acidity as $CaCo_3$	Major (3%)
SULFURIC	Sulfuric Acids	24 Hrs.	7 Days	Acidity as $CaCo_3$	Negligible

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6. Water Supply:

Two sources of water are available, namely the Arthur Kill and the Elizabethtown municipal supply.

Arthur Kill - Approximately 10 mgd of salt water is used for cooling. More than 90 percent of this volume is used on a "once-through" basis. This water is chlorinated continuously for algae and slime control.

Elizabethtown - Approximately 400,000 gpd is purchased from the municipal supply. Roughly 50 percent of this total volume is used to produce steam.

7. Sewerage:

Domestic wastes are handled by twelve (12) septic tanks which are cleaned out periodically by an outside contractor.

8. Processes:

1) Organic Area: The processes for the manufacture of miscellaneous organic intermediates and agricultural products are rather complex and confidential.

2) Strontium Area: The methods for the manufacture of strontium nitrate and strontium carbonate are

given in Kirk-Othmer's Encyclopedia of Chemical Technology, Volume 13.

3) Hydrochloric Area: The process for the manufacture of hydrochloric acid and its by-product -- salt cake -- is the well-known Mannheim furnace process.

4) Amine Area: Strictly a dilution with water process.

5) Central Area: The manufacture of sodium thiosulfate is by a well known commercial process listed in the Encyclopedia of Chemical Technology, Volume 14. Basically the reactants include soda ash, sulfur dioxide and sulfur.

Aluminum chloride solutions are prepared from hydrochloric acid and hydrated alumina, similar to the method in Encyclopedia of Chemical Technology, Volume 2, second edition.

Aluminum sulfate is manufactured from the reaction of bauxite with sulfuric acid as basically described in Encyclopedia of Chemical Technology, Volume 2, second edition.

6) Sulfamic Area: The manufacture of sulfamic acid is by a process basically described in the Encyclopedia of Chemical Technology, Volume 13. The processes and formulations for the associate products are confidential.

7) Silicate Area: The processes for the production of glass and various grades of sodium silicate solutions are the common commercial ones with slight modifications (sand and alkali salts).

8) CP Reagent Area: Purification processes where the technical grade commodities are upgraded to reagent grade quality.

9) CSA - SO_3 Area: The manufacture of chlorosulfonic acid basically is the method described in the Encyclopedia of Chemical Technology, Volume 5 (union of sulfur trioxide and dry hydrogen chloride gas).

Sulfur trioxide is produced by the distillation or stripping of the excess sulfur trioxide in oleum as mentioned in Encyclopedia of Chemical Technology, Volume 13.

10) Sulfuric Area: Various strengths of sulfuric acid are produced by the Contact process described in detail in the Encyclopedia of Chemical Technology, Volume 13.

WATER POLLUTION ABATEMENT PROGRAM

9. Waste Loadings:

Waste loadings, as supplied by the company, are based on raw material yield evaluations -- not flow. It was felt that data presented in this manner were more representative since the product line at the Grasselli plant changes frequently, and because no accurate flow figures exist.

182m

Total Wastes (lbs/day) - Jan 1-July 31, 1965

Days/210 days	Acid as $CaCO_3$	NH_4-N Org-N	NO_2-N NO_3-N	Red Salts	Misc Org	Phenol
190	22,800	390	520	-	50	-
100-140	6,300	680	20	2230	1720	-
60-90	1,700	10	-	-	-	2500
18-40	12,800	1330	-	-	1770	-

10. Waste Treatment:

The majority of the acidic wastes are neutralized either at their point source or in neutralizing pits or boxes. A portable neutralization unit is utilized to handle the acidic washings from tank cars, tank trucks or other equipment.

Several settling ponds (40 to 50 feet in diameter by 12 feet in depth) are located strategically on the plant. These ponds are cleaned periodically by schedule. The organic area also has a collecting tank (approximately 7 feet in diameter and 6 feet in height) which acts as a settling basin and catch tank for any slug of waste inadvertently discharged.

183m

Paul DeFalco

FMC Corporation, Inorganic Chemicals Division

Carteret, New Jersey

1. Organization:

The subject plant is located at 500 Roosevelt Road, Carteret, New Jersey, adjacent to the Arthur Kill. A manufacturing plant was established at this location in 1899 to produce inorganic phosphates. About 1914, the production of baking powders was added to the operations at this location. In 1942, the production of phosphoric acid by combustion of phosphorus was started. Previously the acid had been produced by the wet process.

Main offices for the Inorganic Chemicals Division are in New York City.

2. Products:

The principal products are a full line of sodium and potassium phosphates and phosphoric acid. A minor amount of baking powder and barium nitrate is also produced.

3. Raw Materials:

Principal raw materials are phosphorus, caustic soda, soda ash and caustic potash. Some additives for dry mixing with baking powder are purchased. Small amounts of nitric acid and barium carbonate are used to produce barium nitrate.

4. Operations:

Major production units operate 168 hours per week, while minor ones operate five days per week. Barium nitrate production is on approximately a two-day-a-week basis.

5. Employees:

Present employment is 250 persons.

6. Water Supply:

Approximately 145 mgy (million gallons per year) of fresh water are purchased from the Middlesex Water Company. About 97 mgy of these are used in processing and are primarily lost by vaporization while the balance of 48 mgy are used for boiler feedwater. Approximately 4.4 mgy are recirculated as condensate.

Cooling water is pumped from the Arthur Kill at an annual rate of 660 mgy.

7. Sewerage:

All domestic wastes are discharged to the Carteret sewer system.

Cooling water is returned to the Arthur Kill through the North Outfall and the South Outfall.

WASTE CONTROL

8. Phosphoric Acid:

The phosphoric acid unit is cooled by vaporization of fresh water to steam and with recirculating condensate. The condensate is cooled with sea water in a liquid-liquid heat exchange.

9. Inorganic Phosphate Reactions:

All reactions are heated to speed reaction rate and maintain high concentrations in solution. Heating is accomplished with steam coils.

10. Drying and Cooling:

In the south plant where the products are dried, cooled and dry mixed, the outside of the product coolers are cooled with sea water.

11. Closed Loop:

From the oxidation of phosphorus, considerable excess heat is available for the evaporation of waste process liquids so that the material may be returned to process.

12. Housekeeping:

Spilled materials and floor sweeping are scavenged and disposed of off the premises.

SOURCES OF WASTE

13. Barometric Condenser:

There is one barometric condenser with an entrainment separator in the barium nitrate production unit of a patented design which prevents carryover into the salt water side.

14. Yard Drainage:

Runoff from the ground surface and roofs discharges to the Arthur Kill and is not normally sampled during waste surveys.

15. Waste Survey:

At the request of Interstate Sanitation Commission and the New Jersey State Department of Health, the waste cooling water returning to Arthur Kill was sampled between

May 18 and June 4, 1965. The total rate of pumping was 5.76 mgd. The vent flow (bypassed to the Arthur Kill at the intake) was 0.14 mgd. Two of three discharges were sampled and composited in proportion to daily rate of flow to form the sample for the North Outfall. These two flows were from the phosphoric acid unit and the potassium phosphate unit. Wastewater discharges from barium nitrate production were not included in this sampling program. The wastewater from this operation is discharged as one of three outlets comprising the North Outfall. The South Outfall at 0.29 mgd consisted of waste cooling water from the drying operations. The phosphorus was reported as P_4. The results are tabulated and summarized in Table I of this memorandum.

The intake and waste waters were also analyzed for BOD and the results are presented in Table II of this memorandum.

16. Future Monitoring:

Management reports that a discharge of 300 to 500 pounds per day of P_4 is good practice and the monitoring of the two outfalls is being established as a continuing practice.

TABLE I

Sewer Losses

Date	INTAKE			NORTH OUTFALL(Net)			SOUTH OUTFALL(Net)		
	Flow mgd	P conc. PPM	Vent Flow mgd	Flow mgd	P Conc. PPM	P load lbs/day	Flow mgd	P Conc. PPM	P load lbs/day
5/18/65	5.76	2	0.14	5.33	75	3336	0.29	24	58
5/19		2			29	1290		81	195
5/20		0			57	2535		310	745
5/21		0			33	1468		21	50
5/22		0			35	1557		154	370
5/23		3			107	4760		32	77
5/24		0			22	978		20	48
5/25		0			51	2268		37	89
5/26		0			32	1423		16	38
5/27		0			41	1824		17	41
5/28		0			20	889		37	89
6/2		0			22	978		24	58
6/3		1			47	2090		53	127
6/4		2			13	578		13	31
Avg.					42	1855		60	144

TABLE II

BOD - Mg/Liter

Date	In	North	South
5/18	16	16	15
5/19	16	15	14
5/20	17	10	10
5/21	18	14	15
5/22	14	14	10
5/23	18	11	10
5/24	17	16	7
5/25	11	42	8
5/26	10	11	8
5/27	12	9	6
5/28	17	13	5
6/2	9	17	5
6/3	9	12	6
6/4	8	7	4
Avg.	13.7	14.8	8.8

follows

189m
(table)

Reichhold Chemicals, Inc.

Elizabeth, New Jersey

In October 1965, Reichhold Chemicals, Inc., connected the remainder of their waste discharges into the sewer system of Elizabeth, New Jersey. Prior to this date, approximately 500,000 gpd, or 50 percent of the plant's wastes flow was discharged directly to the Arthur Kill. These wastes were from the Phthalic Anhydride, and the Maleic Anhydride processes.

Reichhold Chemicals, Inc.

Carteret, New Jersey

1. Organization:

This particular unit of Reichhold Chemicals, Inc., was established about 1960 on 42 acres of land purchased from U.S. Metals Refining Co. It is located at the end of Middlesex Avenue in Carteret, past the U. S. Metals Refining Co. Among the other Reichhold Chemicals, Inc., plants, is one located in Elizabeth, New Jersey.

2. Products:

The Carteret plant produces phenolic moulding compound and melamine.

3. Raw Materials:

The raw materials for the moulding compound are:

Phenolic resins (from other RCI plants) received and processed as a solid material.

Wood flour.

Pigments, colorents and lubricants.

The raw materials for the melamine are:

Dicyandiamide.

Anhydrous ammonia.

Alcohols.

4. Operations:

Melamine is produced 168 hours per week and moulding compound is manufactured 120 to 144 hours per week.

5. Employees:

Employment is furnished for 80 persons.

6. Water Supply:

All water is supplied by the Middlesex Water Company at a rate of approximately 3 million gallons per month.

7. Sewerage:

Domestic sewage is treated in septic tanks and absorption fields.

Boiler blowdown (100% make-up) is discharged to a ditch between the RCI plant and Koppers' Forest Products Division.

Waste water discharges to a ditch to the Arthur Kill.

8. Outline of Processes:

Phenolic resins and wood flour are ground and blended with pigments, lubricants, etc., heated and granulated to produce the phenolic moulding compound.

The raw materials for melamine are combined in a direct reaction without any side reactions.

WASTE CONTROL

9 Phenolic Compounding:

There is an extensive vacuum cleaning system in this area for recovery of particulate matter which is returned to process. The floor is swept and the dust collected by the vacuum system. The floors may be occasionally washed with a hose.

10. Settling Tanks:

Waste waters from the phenolic compounding and from the melamine production are settled in underground catch basins before discharge to the respective sewers.

SOURCES OF WASTE

11. Phenolics and Heat:

The extrusion presses for compounding the phenolic moulding material are jacketed and the temperature is controlled by a single pass flow of water tempered with steam. This amounts to about one-half of all water purchased for this plant. There is also a small amount of floor washings. These total wastes are discharged through an opening in a manhole to an open ditch and drains to the Arthur Kill. Some of it is absorbed in the land fill which is slag from U. S. Metals Refining Company.

12. Cooling Tower:

It is reported that there is not any overflow from the cooling tower associated with the production of melamine.

13. Melamine Waste Water:

There is a small flow of settled water from the production of melamine which is normally absorbed by the slag in the yard.

At the time of this meeting some jackets were being experimentally cooled with running water which, combined with other waste water from this area, joined the flow from the phenolic compounding area and drained to the Arthur Kill. If this cooling is beneficial, arrangements will be made to reduce the volume of water discharged.

American Cyanamid Company, Warners Plant
Linden, New Jersey

1. Organization:

The Warners Plant of the Industrial Chemicals Division, American Cyanamid Company, is located at the eastern edge of Linden, New Jersey, at Tremley Point. Operations began in this area in 1916. At the present time approximately 690 people are employed.

The Company's property - 30 acres at this location - is bounded on the south by the Rahway River and on the east by the Arthur Kill. Warehousing facilities are maintained along the western portion of the Jersey Turnpike in Linden, New Jersey - 32 acres. The company also maintains 115 acres of settling lagoons for alum sludges on the southern shore of the Rahway River.

2. Products:

The following items are produced by this facility:

Acid - H_2SO_4

Alum

Mining chemicals - flotation promoters

Surface active agents

Fumigants

Pesticides

Insecticides

Paper resin

Acrylamide

Rubber chemicals

Intermediates

Soil stabilizers

The products listed above are broad categories, as the company produces over 200 different type products.

3. Raw Materials:

Raw materials used include:

Bauxite - production of alum

Sulfur - H_2SO_4

Acrylonitrile - Acrylamide

Phosphorus pentasulfide - pesticides, insecticides and mining chemicals

Organic alcohols

The above mentioned raw materials are those most frequently used. Because of the number of end products there are a variety of smaller quantities of raw materials.

4. Capacity and Operations:

The actual production capacity of the plant and operating schedules are considered confidential information by American Cyanamid.

Processing of two of the main products are described below:

Acid Manufacturing

Molten sulfur is heated in a furnace and mixed with air; SO_2 is produced; catalytic reaction changes SO_2 to SO_3; SO_3 is absorbed into H_2O. Amount of absorption depends upon acid concentration desired.

Alum

Bauxite is digested with H_2SO_4 to extract the Al_2O_3; liquor is decanted off; muds are washed with H_2O to recover Al_2O_3 and then pumped to lagoon area. Products are either sold as liquid or dry.

5. Water Supply:

Two sources of water supply are available, namely, Arthur Kill and the municipal supply from Elizabethtown. Fresh water, consumed at the rate of 800 gpm, or 1.15 mgd, is used for sanitary purposes, equipment cleaning, boiler feed and for manufacturing purposes.

Salt water from the Arthur Kill, consumed at a rate of 28 mgd is used on a once through basis for cooling only. All cooling systems are jacketed with the water pressure higher than the product pressure.

6. Sewage:

All sanitary wastes from the facility are handled by septic tank systems and leaching fields. These installations were approved by the Linden, New Jersey, Board of Health.

WASTE TREATMENT

7. Industrial Wastes:

At the present time there are eight outfalls -- four cooling water and four combination cooling and process water discharging directly into either the Arthur Kill or Rahway River. The four cooling water lines are not monitored by the company. Barometric condensors are used, in the mining chemicals, pesticide and Acrylamide production areas, and, therefore, some carryover of the product line in the cooling water can be expected.

The four combined outfalls, are sampled on a composite basis for either an 8 or 24 hour period, once a week. Results of this sampling for the period 5/14/64 to 2/11/65, are given below:

Outfall	Type Wastes	Average Loading BOD lb. per day	Flow (mgd)
1	Pesticides	3,210	2 to 4
	Surfactants		
	Insecticide		
	Rubber chemicals		
	Mining chemicals		
5	Acrylamide	3,284	1.0
	Misc. Production		
	Paper resin		
6	Pesticides	176	0.4
8	Mining Chemicals	1,299	1.0
	Xanthate		

At the present time, with one exception - oxidation of wastes from monomethylamine process - all wastes are

10b discharged to the receiving waters without "end-of-sewer" treatment.

Information on the temperature and DO levels of the Arthur Kill in the vicinity of the discharges - from the period 5/14/64 to 2/18/65 - have been supplied by the American Cyanamid Company.

WATER POLLUTION ABATEMENT PROGRAM

At the present time, the Warners Plant of the American Cyanamid Company is under formal orders from the New Jersey State Department of Health to abate pollution and discharge no more than 2,000 to 2,500 pounds per day of BOD.

Back in 1960, the plant was discharging approximately 10,000 pounds of BOD per day. The plant since this time has undergone appreciable growth, and if it were not for in-plant process design changes which kept the figure at 10,000 pounds, it is estimated that the loading would have reached as high as 16,000 pounds per day.

Within the past year, the company has initiated major process changes in its Acrylamide production. These changes have resulted in the recovery of by-products for the company and have also reduced the BOD loading from this operation. When modifications are completed it is anticipated that the load from this operation will be approximately 500 pounds of BOD per day, where previously loads averaged 2,500 pounds per day.

8. Future Pollution Program:

By the end of 1966, the company will have completed a major program designed to reduce its BOD load from approximately 7,000 pounds per day to 2,000 - 2,500 pounds. The program provides for the barging of aqueous effluents - high concentration low volume - to sea, 110 miles, for disposal. Permits therefore have been obtained from the U. S. Corps of Engineers which were granted after clearance by all Federal and State agencies concerned.

On-shore collection and storage facilities will be installed at the plant site. The effluent will be loaded and barged to sea by a barging contractor under a contract of affreightment which is currently being negotiated. The effluents to be barged essentially fall into three classifications:

1. Organic phosphate pesticides.
2. Mercaptans.
3. Other phosphorus - sulfur compounds.

The total aqueous effluents to be barged will be 8.2 million gallons per year. The percentage of organic contaminants in these effluents follows:

1.5% ethyl mercaptan

0.5%	O,O-diethyl S-(ethylthiomethyl) phosphorodithioate
0.5%	O,O-dimethylphosphorodithioate of diethylmercaptosuccinate
0.5%	O,O-diethyl O-p-nitrophenylphosphorothioate
0.05%	O,O-dimethyl S-(methoxycarbonylmethyl) phosphorodithioate
4.0%	toluene
0.05%	monomethylamine
0.05%	benzene
0.5%	sodium dioctyl sulfosuccinate (surfactant)
0.5%	sodium O,O-dimethylphosphorodithioate

American Cyanamid Company
Woodbridge, New Jersey

1. Products:

There are about 77 products made in this plant. These are classified under one of the following categories:

Stearates)
Specialty chemicals) Company officials consider quantity
Catalysts) information confidential
Mining chemicals)

2. Raw Materials:

There are approximately 130 raw materials. The major ones are:

Petroleum waxes)
Vegetable & mineral base oils) Company officials consider
Fatty acids) quantity information
Acids & alkalis) confidential
Acrylonitrile)
Oxides of iron)
Sodium chloride)

3. Capacity:

The plant is presently operating somewhat below maximum capacity. The plant's future growth is expected to be of such a nature that its effluent will remain approximately at its current level.

4. Operations:

This installation operates essentially 24 hours per day, 7 days per week. About half of the employees are on day shifts and the remainder cover night shifts.

5. Water Supply:

About ninety-five percent of the water used, or approximately 90,000 gpd, is obtained from a well on the plant property. The remainder - approximately 5,000 gpd - is purchased from the Middlesex Water Company.

SOURCES OF WASTES

Product Line		Estimated Flow (gpd)	Source	Constituents after treatment
1.	Sulfonated Oils	1,000	Process + cooling	400 ppm Total (Na_2SO_4, NaCl, glycerol)
2.	Wax Sizes	250	Cooling + floor washing	Trace - wax, gum, Dowicides, Dispersing Agent
3.	Chrome acetate	-	Floor washing	Trace - chrome salt
4.	Drum dryer	14,000	Floor washing	40 ppm Total-polyacrylates, $MgSO_4$, $ZnSO_4$
5.	Stearates	25,000	Filtrate	1580 ppm Total - $CaCl_2$, NaCl
6.	HI-3 catalyst	100	Floor washing	Trace - $(NH_4)_2Cr_2O_7$, Cr_2O_3, Fe_2O_3
7.	FM-2 catalyst	-	Electrode cooling	None
8.	Lab	4,000		
9.	Aluminum acetate	150		Trace - $CaSO_4$ Al. acetate
10.	Scrubber	3,500		500 ppm NH_3
11.	Sanitary	2,000		
12.	Cooling water	40,000		
13.	Softener	5,000		250 ppm NaCl
		95,000		

BOD results mainly from glycerol, dispersing agents, and acetates.

No barometric condensers are used.